Topanga Source ID Study
FINAL Report Dec 2012- August 2014

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES
(Attached Separately)

APPENDIX A - Data Details
APPENDIX B - Sampling Event Photos
APPENDIX C – Benthic Macroinvertebrate Data
APPENDIX D - Technical Advisory Committee
APPENDIX E - Community Outreach
APPENDIX F - Diatom Data
APPENDIX G - QA/QC Plan
APPENDIX H - Septic System Map and Plans
APPENDIX I – Results of Enterovirus Contamination Study
APPENDIX J – UCLA Publications

LIST OF ABBREVIATIONS

AB411 – Assembly Bill 411: Ocean water standards
AB885 – Assembly Bill 885: OWTS policy
ATP – Microbiological alternate test procedure
BC – Ballona Freshwater Marsh
BH – BacHum Taqman human-associated assay
BMI – Benthic macroinvertebrates
BMP – Best management practices
BO – Beach outlet (located directly in front of lagoon, City sampling site)
BR – Brookside Drive (1700 m from ocean)
BSA – Bovine Serum Albumin
BT – Bacillus thuringiensis
BU – Beach Upcoast (located 175 m west of the beach outlet at the lagoon)
CFS – Cubic feet per second
CFU – Colony-forming unit
COC – Chain of custody
CPOM – Course particulate organic matter
D18 – Diatoms only
DO – Dissolved oxygen
EC – Escherichia coli
ENT – Enterococci
EPT – Ephemeroptera, Plecoptera, Trichoptera
FF – First flush = Rain events where greater than 0.75” of rain falls during a single storm.
FFG – Functional feeding group
FIB – Fecal indicator bacteria
H20 – Soft bodied algae and diatoms combined
HF- HF183 Taqman human-associated assay
IMS – Immunomagnetic separation method
LACDBH – Los Angeles County Department of Beaches and Harbors
LACDPH – Los Angeles County Department of Public Health
LACENVR – Los Angeles County Environmental Health
LARWQCB- Los Angeles Regional Water Quality Control Board
LG – Lifeguard station (located on Topanga Beach)
LOD – Limit of detection
LT – Lower Topanga (annual stream survey site beginning at 3200 m)
MC – Malibu Creek
MM – Mile marker
MPN – Most probable number
MST – Microbial source tracking
Narrows – The section of Topanga Creek between Owl Falls (6500 m) and Scratchy Trail (4800 m).
ND – Not detected
NRR – Non-removal reach for crayfish project (3700 -3900 m)
NTU - Nephelometric Turbidity Unit

OF – Owl Falls (located 6500 m upsstream of the ocean)
OWTS – On-site wastewater treatment system
PBS – Phosphate buffering saline
PCH – Pacific Coast Highway
PHAB – Physical Habitat Data collected with SWAMP protocol
PPM – Parts per million
QA/QC – Quality assurance / quality control
qPCR – polymerase chain reaction quantification
RA – Relative abundance (%)
RCDSMM – Resource Conservation District of the Santa Monica Mountains
RKM – River kilometer
RLU – Relative light units
ROQ – Range of quantification
RR – Removal reach for crayfish project (3500-3700 m)
RV – Recreational vehicle
S2 – Soft bodied algae only
SC-IBI Southern California Index of Biotic Integrity
SCC-IBI – Southern California Coastal Index of Biotic Integrity
SCCWRP – Southern California Costal Water Research Project
SIPP – Source Identification Protocol Project
SP – Snake Pit (located 300 m upstream of the ocean)
ST – Scratchy Trail (located 4800 m upstream of the ocean)
SWAMP – Surface Water Ambient Monitoring Program
SWRCB – State Water Resources Control Board
TAC – Technical Advisory Committee
TB – Topanga Bridge (located 3600 m upstream of the ocean)
TC – Total coliform
TKN – Ammonia and organic nitrogen
TL – Topanga Lagoon
TMDL – Total maximum daily load
TV – Tolerance value
UCLA – University of California, Los Angeles
UCSB – University of California, Santa Barbara
USC – University of Southern California
UT – Upper Topanga (annual stream survey sampling site beginning at 4500 m)
UTM – Universal Transverse Mercator
WQO – Water Quality Objectives
WY – Water year

EXECUTIVE SUMMARY

The purpose of the Topanga Source Identification Study was to examine the various locations where bacterial exceedances of fecal indicator bacteria (FIB) are occurring and to use state-of-the-art methods to identify the possible sources of fecal contamination (human, gull, dog, horse) in lower Topanga Creek and at Topanga Beach. Based on the information gathered, we have identified and suggest some Best Management Practices that could potentially reduce, mitigate or eliminate these inputs and thus improve water quality at Topanga Beach.

Topanga Beach received poor wet weather water quality ratings between 2006 and 2014. The beach exceeded the water quality objectives set for Fecal Indicator Bacteria (FIB) from the Ocean Standards (AB411) based on weekly samples collected by the City of Los Angeles Environmental Monitoring Division. This happened frequently enough for Topanga Beach to be identified by Heal the Bay as the 4th most polluted beach in the state for the 2010-2011 season and as the 10th most polluted in 2011-2012. From 2012-2014, overall precipitation levels were very low, and water quality throughout the Santa Monica Bay was excellent. However, Topanga Beach was listed as “B” for summer dry (April – October 2012), “C” for winter dry (Nov 2012– Mar 2013), and “F” for wet weather year-round (Heal the Bay 2013). In 2014, summer dry was "A", winter dry "B", and "C" for wet weather year-round (Heal the Bay 2014). One of the goals of the Ocean Standards water quality objectives was to reduce the number of exceedances during the recreational season (April 1- October 31). In 2013 there were 17 exceedances and thus far in 2014 there have been four confirmed exceedances.

The information provided in this report includes all data collected from December 2012 through August 2014. Input from the Technical Advisory Committee throughout the study (2012-2014) helped identify data gaps, as well as refined and focused the sampling efforts.

Hypotheses and Results

At the start of the study, we identified the following hypotheses to test.

HYPOTHESIS 1. ***Upper watershed sources of FIB are not conveyed to the beach via the creek.***

Result: The upper watershed is not contributing to the exceedances observed at Topanga Beach. Based on the data collected thus far, FIB levels in the creek upstream of the lagoon do not appear to correlate with exceedances observed at Topanga Beach.

Data indicated that except for a few occasions, mainly associated with either rain events or observed transient activity, fecal indicator bacteria levels were unlikely to affect surfzone and lagoon water quality. Samples collected from the Pacific Coast Highway (PCH) Bridge, within the lagoon and along the beach in the ocean had clearly different patterns than those observed upstream within Topanga Creek.

HYPOTHESIS 2. ***Concentrations of FIB and/or markers and nutrients decrease as the creek flows downstream from town through the Narrows. Benthic macro-invertebrate community species diversity, sensitivity, and abundance increases as the creek flows downstream.***

Result: Concentrations of FIB and nutrients decrease as the creek flows downstream from town through the Narrows.

Conditions of FIB in the creek in the Narrows section, located between Owl Falls (6500 m) and Scratchy Trail (4800 m) appear conducive to a decrease in EC and ENT levels and observed levels of human- and dog-associated marker.

Nutrient levels in Topanga Creek and Lagoon are low overall, and despite the very low flow conditions in 2012-2014, the pattern of decreasing levels of nutrients as the creek flows downstream are consistent with those observed in previous studies (Dagit et al. 2004). Exceptions to this pattern were observed during rain events and associated with transient activities.

Result: From Owl Falls to Scratchy Trail and Topanga Bridge, benthic macroinvertebrate species diversity increases as the creek flows downstream. However, overall SCC-IBI scores are low throughout Topanga Creek.

The biotic integrity of benthic macroinvertebrate communities in Topanga Creek, as measured by Simpson's Diversity Index and SCC-IBI, was highest at Scratchy Trail and Topanga Bridge. Lower downstream, Brookside Drive showed significant disturbance, as this site ran dry twice throughout the course of the study. Throughout the watershed, both low and high flow conditions resulted in decreased IBI scores. Average total coliform in 2014 was also significantly correlated to low SCC-IBI total and EPT taxa scores. Only 16 of a total of 35 samples analyzed (2003-2014) had 500 or more individuals, which limited the ability to apply the SCC-IBI metric. A regional comparison of Topanga Creek to other Santa Monica Mountain sites (Malibu, Cold Creek, Arroyo Sequit, Solstice) revealed that since 2003 Topanga has had very low scores, second only to Malibu. The onset of drought in 2002 has had significant impacts on Topanga Creek, in terms of both SCC-IBI scores and species composition. In spite of low SCC-IBI scores, Topanga remains an important reference creek for the region, as it continues to flow throughout most of the reaches where others run dry.

HYPOTHESIS 3. ***FIB and/or pathogens are not leaking from faulty septic systems in the lower watershed, from septic systems along Pacific Coast Highway in Topanga State Park or from the County Lifeguard facility.***

Result: Testing of the septic systems along PCH indicated that the system at the Ranger residence at the Topanga Ranch Motel was possibly leaking, so repairs were completed in summer 2013. It is no longer leaking. The system at the Feed Bin was also a potential source of leachate and requires repair and further testing to evaluate the input potential into Topanga Creek. The other systems within Topanga State Park do not appear to be leaking, nor does the County Lifeguard facility.

Although testing in Summer 2013 indicated that the majority of septic systems in the area adjacent to Topanga Lagoon are not likely to be actively contributing any leachate at this time, there are several studies that suggest that there can be a long lag time between input into the ground water table and emergence in either the ocean or a lagoon (Stone Environmental 2004). Since most of these systems have only been capped since 2008, additional testing in the future may be required in order to conclusively document any potential inputs.

HYPOTHESIS 4. ***Lower watershed and/or lagoon sources of FIB (human and non-human inputs such as gull, dog, etc.) are correlated with exceedances at Topanga Beach.***

Result: Contributions from Topanga Lagoon are correlated with FIB levels in the ocean during rain events and when the lagoon is connected to the ocean directly.

FIB levels are significantly increased when the lagoon is breached and connected to the ocean regardless of winter or recreational season.

Result: Dogs and gulls are a significant source of fecal contamination to the lagoon and ocean and likely contribute to exceedances of ENT state water quality standards at the ocean and lagoon sites.

Gull levels were detected 94% of the time in lagoon samples and 80% of the time in ocean samples, indicating that gulls are an important and chronic source of fecal contamination to Topanga Lagoon and ocean sites. Dog marker levels in Topanga waters were similar to those measured at Rosie's Dog Beach in Long Beach, CA and were detected on average 71% of the time at ocean sites and 64% of the time at lagoon sites. This confirms that dog waste is also a significant source of fecal contamination to Topanga Lagoon and ocean.

Result: Human marker was detected infrequently in the creek, lagoon and ocean.

In Topanga, continued sampling for human-associated marker is recommended. During Year 1 (July 2012 to June 2013), human-associated marker was detected in the ocean on five sampling dates, including first flush, and also on four dates in the lagoon, one of which was first flush. There was a total of seven dates with either ocean or lagoon detection. Results from Year 2 (July 2013 – June 2014) are encouraging, as human marker was detected in the ocean on just two days, one of which was first flush. For the lagoon, human hits were observed only during the first flush event of Year 2. Further sampling is needed to determine if this trend continues and if it will continue to occur under non-drought conditions.

Summary of Results

This DRAFT FINAL report (9.23.14) for the Topanga Source Identification Study includes extensive discussion of the following specific efforts in accordance with the deliverables required by the grant, however a summary of the most important results is included here for ease of use.

1. **Present physical and chemical water quality conditions in the main stem of the creek, and along Topanga Beach and Lagoon.** (See Chapters 6-7)

    - Rainfall was below normal for both years the study took place, and significant rain events were few and far between. Therefore, flow was consistently low throughout the study period as well.
    - The average wetted width of the creek remained fairly constant throughout the study but average depths decreased in some locations in 2014.
    - Water temperature, pH, and specific conductivity were relatively stable and consistent with previous data collected (Dagit et al 2004, 2000-2012 RCDSMM unpublished data).
    - Habitat types remained consistent during the course of the study with riffles, runs and glides dominant in the lower reach of the creek (below 3600 m) and a more complex mix of flow habitats (cascade/fall, riffle, run, glide and pool) found upstream. None of the flow habitats in study reaches were dry during either year.
    - Geomorphology and gradient affect the types of flow habitats present, with the lower gradient reach below 3600 m (<3%) being dominated by run-riffle complexes and the upper gradient (3-6%) being pool dominated.
    - Smaller substrates such as fines and gravel were more frequent in the lower reach, whereas larger substrate such as cobbles, boulder, and bedrock were more frequent in the upper reach, which has a higher gradient (> 3%).
    - Instream habitat complexity includes abundance levels of filamentous algae, aquatic macrophytes, boulders, woody debris, undercut banks, overhanging vegetation, living tree roots and artificial structures. In 2014, both the lower and upper reaches had greater habitat complexities than in 2013 despite the low flows.
    - The proportions of cover values for several riparian vegetation types were also estimated for the lower and upper reaches. Trees and saplings > 5m had the highest proportion of sparse cover in both the lower and upper reaches.
    - Overall, both reaches of Topanga Creek have relatively stable banks that can support a complex assemblage of aquatic organisms. The higher level of fines and gravel in the lower reach are highly mobile. Snorkel survey and habitat typing focused on habitat for endangered steelhead trout documented the pulses of sediment moving downstream with storm events over time (Dagit and Krug 2011). While the specific

location of the sediment slugs varies over time, and results in decreased pool habitat in certain reaches, the overall amount of pool habitat and refugia for fish remained fairly constant, despite a very wet year in 2005. Overall, channel morphology has also remained fairly constant over time (Dagit and Krug 2011).

- In-situ parameters (water temperature, dissolved oxygen, pH, conductivity, salinity) were, in general, within the standard tolerance ranges for wildlife.
- Nutrient and algae levels were, in general, low throughout the study period, with only occasional exceedances.
- On average, nitrate and orthophosphate levels decrease from Owl Falls (OF, 6500 m; the site closest to town) downstream to the lagoon but this decline is more pronounced between OF and Scratchy Trail (4800 m)
- On average, Brookside Drive (BR, 1700 m) had the highest levels of Ammonia.
- Owl Falls had the highest nutrient levels and Scratchy Trail has the lowest nutrient levels on average.

2. **Microbial source tracking results.** (See Chapter 3)

- The lagoon is a source of FIB to the ocean. FIB levels are significantly increased when the lagoon is breached.
- Levels of FIB and all markers increase from the most downstream creek site (SP) to the lagoon. The lagoon may serve either as a location where microbial levels may be increasing due to growth (FIB) or to the presence of new inputs (FIB and markers).
- FIB in the surfzone do not appear to originate from an upstream creek source, except on days when both flow and FIB levels in the upper watershed are elevated. Days where creek input had potential to significantly impact downstream levels occurred on two sampling dates during this study, including the first flush event during year two of the study.
- Winter samples were four to eight times higher than samples for the recreational season for the dog and gull marker, indicating that these markers follow a seasonal trend and may have more of an impact to water quality during the winter.
- Dog and gull marker levels indicate a significant source of fecal contamination to the lagoon and ocean, and both dog and gull sources are likely contributing to exceedances of ENT and EC state water quality standards at the ocean sites. When ENT levels were in exceedance, gull marker levels were higher than when ENT levels were in compliance at BO, and TL. When dog marker levels in Topanga water samples were compared to levels at two reference beaches and one dog beach, dog marker levels at Topanga were similar to levels at the dog beach. No dog marker was detected at the two reference beaches sampled (Dockweiler and Malibu).
- Human marker was detected infrequently in the lagoon and ocean (13%). Average human marker values were higher at ocean sites when ENT levels were in exceedance vs. in compliance of state water quality standards. During Year 1 (July 2012 to June 2013), human-associated marker was detected in the ocean on five sampling dates,

including first flush, and also on four dates in the lagoon, one of which was first flush. There was a total of seven dates with either ocean or lagoon detection. Results from Year 2 (July 2013 – June 2014) are encouraging, as human marker was detected in the ocean on just two days, one of which was first flush. For the lagoon, human hits were observed only during the first flush event of Year 2.

3. **Description of human health risk associated with human and non-human sources of fecal contamination. (**See Chapter 4)

    - Previous studies have well established that there is a correlation between the levels of FIB in recreational waters and incidence of illness when the likely source of fecal contamination is human.
    - The risks associated with exposure to non-human sources of fecal matter in recreational water are still not well characterized, as epidemiological data on this topic are insufficient. However, there is some evidence in the literature for greatly reduced risk in water polluted by nonhuman fecal matter.
    - Interest is growing in quantitative microbial risk assessment (QMRA) as a framework for understanding risk of illness in recreational water exposure.
    - Ongoing research is required to fill data gaps before QMRA can be applied as an effective approach for predicting risk in recreational coastal waters. While US EPA has opened a door, site-specific water quality criteria (as would be derived from QMRA) are still not accepted under California regulations.
    - For Topanga to be a candidate for QMRA in the future, testing for host-specific markers and pathogens (viruses) must be continued to assess the downward trend observed in human-associated marker and to monitor reductions in dog and gull pollution as sources. These measurements must continue as the drought ends so the role of the creek can be fully assessed. Depending on those results, it may be possible to conduct a thorough risk assessment and move towards site specific objectives.

4. **Examination of changes in macro-invertebrates, aquatic species of special concern and endangered fishes in relation to water quality conditions.** (See Chapters 8-11)

    - Benthic macroinvertebrate Southern California Coastal Index of Biotic Integrity (SCC-IBI) scores increase from upstream to downstream. The lower scores in the downstream sites appears related to lack of flow.
    - Both the high and low flow conditions resulted in decreased SCC-IBI scores.
    - Although the SCC-IBI score for Topanga Creek was initially documented as Good (46) in 2001, analysis of the samples collected between 2003 -2014 range from Fair to Very Poor, and in fact 19 of 35 samples had too few individuals to apply the metrics.
    - Average Total Coliform per site in 2014 (excluding first flush) was significantly and negatively correlated to EPT taxa, and also to total SCC-IBI scores ($F<0.05$, $R2=0.88$, $R2=0.64$). Average nutrient levels did not seem to be correlated with SCC-IBI scores.

- Drought conditions have reduced IBI scores throughout the region
- Crayfish removal had no effect on water quality or nutrient levels.
- Crayfish removal improved BMI community compositions while on-going but the effect was not observed two months after removal ceased.
- Crayfish removal could be beneficial in improving ecosystem health and nutrient cycling within the creek.
- Examination of diatom and soft-bodied algae communities can provide secondary indicators and multiple lines of evidence to better characterize the responses of southern California creeks to both natural (floods, wildfire) and anthropogenic inputs will allow for better understanding of the dynamics of aquatic systems.
- Diatom data from Topanga 2013-2014 provides a baseline snapshot of low flow conditions.
- A total of 125 diatom species were observed in Topanga Creek in 2013-2014. 46 species, many of them of cosmopolitan distribution, were common to both years, with 40 different species found only in 2013 and 39 species found only in 2014.
- Cladophora glomorata is the most common taxa found throughout southern California, appears to be a reliable indicator of high total Nitrogen (3.5 mg l-1) (Stancheva et al. 2012) and was also the dominant species observed in both Topanga and Malibu Creeks despite their different nutrient levels. This could possibly be a result of inability to differentiate between species in the same genus that appear taxonomically similar, but in fact represent different species with different tolerance preferences. It could also mean that further refinement of the tolerance limits and preferences is needed.
- Applications of three different indices of biologic integrity showed a consistent picture between sites and creeks for the soft body algae only (S2), diatoms only (D18) and combination of both (H20). These metrics from the Southern California Index of Biotic Integrity (Fetscher et al. 2014) are only recently available, so it is not yet possible to compare the snapshot of conditions in Topanga and Malibu Creeks in 2013 to other sites regionally.

Identification of potential remedial actions and BMP's. (See Chapter 12 and 13)

We recommend that the following potential actions are considered for implementation in order to reduce exceedances at Topanga Beach and improve the water quality and habitat in the upper watershed. Additional recommendations for further studies to continue the investigation of sources of bacteria and other pollutants are detailed in Chapter 13.

Recommended BMP's for Topanga Beach:

1) Restore Topanga Lagoon and Lower Topanga Creek State Park. This is a longer-term project, but by restoring natural function to Topanga Lagoon, it would be possible to not only reduce the bacterial sources but also improve habitat for a variety of endangered species, especially tidewater gobies and southern steelhead trout.
2) Continued enforcement of the County code and additional signage may reduce impact and presence of dog feces. The marker data documents a rise in dog associated markers in the winter months when lifeguard supervision and peer-pressure from beach visitors are reduced. During the study, dogs and dog feces, were routinely observed on the beach. The winning student posters have been affixed to the lifeguard station to assist with public outreach.
3) Continue coordinated enforcement to reduce the number of homeless and transients camping in and around the beach and under the PCH underpass. A mass balance calculation of input of one direct deposit to the lagoon (~200g of human feces) was calculated to result in an exceedance of ENT (Riedel et al. 2014 submitted). Direct deposits were observed at both the lagoon and beach on multiple occasions during the study. Direct deposits associated with the transient population is again an enforcement issue but one that could potentially reduce exceedances.
4) Continued maintenance and monitoring of the Lifeguard Station shower and restrooms. Some drainage from the showers directly to the beach was observed on several occasions. When tides are high or storm events shift the lagoon mouth downcoast in front of the building, there is potential for this to become a source.
5) Investigate possible installation and maintenance of culvert filters along Pacific Coast Highway at Topanga Beach to prevent direct road surface run-off spills into Topanga Lagoon.
6) Upgrade the septic systems at the Topanga State Park along PCH as conditions change and opportunities arise. As the lagoon park plan evolves, incorporating state of the art septic systems into any visitor serving facilities is recommended.
7) Increase outreach to commercial facilities that are on septic systems along the beach. The Feed Bin has the last remaining septic system that is connected to a seepage pit. Upgrading that system should be a priority.
8) Additional patrolling of the state park for transient and RV dumping activity could help with any exceedances in the creek, similarly, further enforcement of the no-dogs-allowed-on-beach rule would probably help with the FIB issues at the beach/lagoon.
9) Increase public outreach concerning the problem with dog feces pollution. While changing behaviors is difficult, peer pressure to pick up after your dog, as well as to reduce the number of dogs visiting the beaches could help.
10) Participate in future monitoring and develop funding to initiate a quantitative microbial source identification study to evaluate the potential for developing appropriate site specific objectives.

Recommended BMP's for the Topanga Creek Watershed:

Although it does not appear that inputs into the upper watershed are associated with the exceedances at Topanga Beach, there are indications that they negatively impact the creek's ecosystem. A number of BMP's could be implemented throughout the watershed in order to reduce inputs to the creek and possibly improve overall conditions in Topanga Creek.

1) Establish a community outreach program to inform residents of potential septic system impacts to the creek and encourage them to upgrade their existing septic systems by installation of effluent-filters in septic tank outlets to reduce particulates into leach fields or seepage pits, thus reducing bacterial and nutrient contamination potential. The community outreach program should include identifying funding sources to assist property owners in upgrading their septic systems.
2) Establish a community outreach program to inform residents of potential impacts to the creek from sub-surface and surface graywater discharges.
3) Through community outreach, encourage the installation of additional trash receptacles behind Topanga Market and Abuelita's.
4) Through community outreach, encourage the availability of public restrooms in Topanga Center.
5) Continue coordinated efforts to remove transient encampments and illegal marijuana farms located adjacent to the creek.
6) Implement the Santa Monica Mountains Local Coastal Program policy for existing equestrian facilities to encourage such facilities to come into compliance with all of the LCP policies and regulations as soon as possible.

Additional recommendations for future research are included in Chapter 13.

Documentation of community participation:

One important element of this study was to educate the local community and engage elementary through undergraduate students in the investigation of bacterial sources and pollutants in Topanga Creek. To that end, the RCDSMM, Watershed Stewards Program Members and Dr. Jenny Jay's team at UCLA provided a series of in-class and field programs reaching over 400 students.

Community outreach documented in Appendix E included:

1) Yearly community meetings (May 2013 and 2014) to highlight care and maintenance of septic systems and graywater systems, share the preliminary results of the study, and discuss potential BMP's.
2) Yearly watershed field class and UCLA mentoring for 5th graders at Topanga Elementary School and 6-8th graders at Topanga Mountain School.
3) In 2014, students participated in an experiment at Topanga Beach to examine decay rates and levels of FIB contained in the sand along the beach. Students worked with their UCLA undergraduate mentors to collect and analyze data and then prepare posters to share results. These posters were presented at UCLA and to the community.
4) Students also participated in a poster contest to explain why dogs on the beach are a problem. The three winning posters are being made into signs that will be posted at Topanga Beach.
5) Yearly neighborhood meeting to discuss "hot spots" and brainstorm solutions. This action was not completed.
6) Two articles per year in the local newspaper and relevant web sites updating results of the study to the community. Copies of the articles are included in Appendix E.
7) Twice yearly training of Stream Team volunteers. Trainings took place on Saturday 1 December 2013, 5 June 2013, and again on 23 October 2013 to train new Watershed Steward and UCLA student interns.

Acknowledgements

First and foremost, we wish to thank Supervisor Zev Yaroslavsky for the financial support for this effort. Chief of Staff Alisa Katz and Deputy Susan Nissman were key to developing a coordinated effort that will not only assist the County in learning more about the water quality issues at Topanga Beach, but will hopefully also provide innovative, cost-effective solutions for making sure the waters of LA County are safe for swimmers, as well as support a viable ecosystem.

Numerous Resource Conservation District of the Santa Monica Mountains (RCDSMM) and University of California at Los Angeles (UCLA) staff, students and volunteers cheerfully got up in the dark for many months to help collect data. We could not have collected and processed the samples without the assistance of: Uriel Cobian, Ian Davies, Steve Harrison, Raven Logiuroto, Sofi Peterson, Gabriel Sloggy, Ken Wheeland, and Steve Williams.

A variety of interns and Watershed Steward members assisted in the benthic macroinvertebrate analysis under the guidance of Jenna Krug, Crystal Garcia and Lizzy Montgomery. We could not have completed the work without your help.

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Dr. Katherine Pease from Heal the Bay graciously answered many questions, provided important data and loaned us a great microscope used to examine the macroinvertebrates.

Dr. Richard Ambrose at UCLA also loaned us equipment to facilitate BMI analysis.

The members of the Technical Advisory Committee provided invaluable information that helped us refine our study plan and examine our results. Members included:

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Purpose (as Proposed in 2012)

How does Topanga Creek decline from an "A" grade creek into an "F" grade beach?

1) Identify the likely sources (both physical location and source, i.e., human, bird, dog, horse, etc.) of elevated fecal indicator bacteria (FIB) at Topanga Beach by testing the creek from MM 2.02 to the beach. Test the hypothesis that the creek is grade "A," and sample in and around the lagoon to fine tune our understanding of when and investigate when and why the beach gets grade "F."
2) Identify best practices or remedial actions that could reduce or eliminate fecal contamination from human or animal sources.
3) Implement K-12 and community education and outreach to engage stakeholders in water quality problems and best management practices to solve them.

This report provides background information, documents methods used, summarizes data gathered and suggests recommended Best Management Practices for moving forward. This report is organized according to standards used in scientific publications, which results in some repetition of methods and results that interconnect between chapters. Our intention is to submit these chapters for peer-reviewed publication, in addition to completing the final report required by this grant.

The intended audience for this report includes County and agency staff, as well as interested citizens, Stream Team volunteers, and our student participants.

Community Outreach and Technical Oversight

Topanga is a small community with many active and concerned stakeholders. The proposed testing meets the needs identified in the Topanga Creek Watershed Management Plan (2002). Input from local experts and agency staff was solicited through the formation of a Technical Advisory Committee, which met in December 2012 to help guide sampling strategy, and again in April and October 2013, April, May and October 2014 to review preliminary results and suggest refinements. In May 2013, a community meeting held at the Topanga Public Library provided a wonderful opportunity to engage property owners in a collaborative effort to understand the preliminary results, and examine acceptable procedures for maintenance, monitoring and implementation of Best management Practices (BMP's) for septic and graywater systems that meet the regulatory standards of AB885. Building on the long-standing effectiveness of the RCDSMM Stream Team, volunteers and local students were solicited and trained to assist in data collection. Another community meeting was held in May 2014 to discuss the results regarding the inputs from dogs at the beach, and included a poster contest which resulted in student posters being deployed at Topanga Beach to educate the community.

Even though this study did not sample in the developed upper watershed, we recognize that inputs from the private inholding areas within the predominately public open space of the watershed could have negative impacts. Reaching out at the neighborhood level to property owners adjacent to previously identified "hot spots" is a difficult and sensitive endeavor. Due to the focused attention on the beach and lagoon, we did not conduct these meetings, however, we did provide detailed information to the whole watershed through articles in the Topanga Messenger, on Zev's blog and through community meetings.

In order to be successful in reducing pollutants entering Topanga Creek, Lagoon and Beach, an on-going education program was identified as critical. In-class watershed classes were provided to the Topanga Elementary School (TES) kindergarteners. In both spring 2013 and 2014, 5th grade students from TES, along with 6-8th graders from the Topanga Mountain School (TMS) participated in a collaborative project with UCLA undergraduate students to develop and test hypotheses about water quality that included both in-class and field studies. This culminated with the students working with their UCLA mentors to produce scientific posters explaining their hypothesis, results and conclusion that they presented on campus at UCLA and to the community. This was a great way for students to make the connections between what goes down the kitchen sink/tub and pollution in the creek. Getting the students into the ocean to collect and analyze samples was not only great fun, but gave them a real sense of how research works. The posters summarizing the student projects are found in Appendix E.

Need for Project

In spite of the removal of houses and their accompanying septic systems within the Rodeo Grounds area of the lower watershed (and other coastal engineering solutions described below), Topanga Beach received poor wet weather water quality ratings between 2006 and 2014. The beach has exceeded the water quality objectives set for Fecal Indicator Bacteria (FIB) based on the Ocean Standards (AB411) obtained from weekly samples collected by the City of Los Angeles Environmental Monitoring Division. This happened frequently enough for Topanga Beach to be identified by Heal the Bay as the 4th most polluted beach in the state for the 2010-2011 season and as the 10th most polluted in 2011-2012. No systematic sampling of the creek or adjacent up and downcoast reaches of the beach had been done since 2004.

Over the past few years, a number of actions have been implemented to reduce possible bacterial contamination of Topanga Beach. In 2008, Los Angeles County Department of Beaches and Harbors upgraded their septic system associated with the restrooms and lifeguard station. Since 2008, the septic systems located within the former Rodeo Grounds Road and Snake Pit area have been removed. The septic systems associated with the Topanga Ranch Motel (ranger house only), Reel Inn, Cholada's, Rosenthal Winery, and the Topanga Feed Bin have been sealed and are now being pumped weekly or as needed in compliance with California Department of Parks and Recreation requirements.

Topanga Creek was listed by the Regional Water Quality Control Board 303(d) list for lead in the upper watershed and bacteria at Topanga Beach. No other pollutants of concern have been listed for the watershed. Topanga Creek has no stormwater conveyance systems per se, but in actuality stormwater is "conveyed" and enters the creek in a variety of ways via surface flow, private and public culverts and natural drainages.

A variety of analytical methods now allow for identification of specific source-associated molecular markers, including human, dog, horse, and gull. In collaboration with the State of California Source Identification Project (SIPP), this MST study was completed in order to provide insight concerning sources of elevated FIB in the Topanga watershed.

The funding contributed by the County has:

1) enabled comprehensive sampling for FIB and molecular markers within the Topanga Creek watershed that has complemented and expanded on hypotheses and results generated during extensive SIPP MST study of the Topanga watershed;
2) allowed for analysis of the benthic macroinvertebrate Southern California Coastal Index of Biotic Integrity in Topanga Creek, which has provided a greater understanding of the biological health of the Topanga watershed;
3) provided sufficient information to develop/recommend possible remedies to the problems identified; and provided substantial outreach and education to local K-12 students and the general public.

1 Background Information (Previous Studies prior to 2012)

Functional bacterial communities are essential to both human and ecosystem health. The focused sampling and monitoring provides the County and the Regional Water Quality Control Board with information that will assist in identifying potential FIB sources and reducing contributions from these sources that lead to exceedances of state bacterial water quality standards.

This study provided an interesting opportunity to examine the biology of the Topanga Creek watershed as well as mechanisms that allows assimilation of fecal and nutrient pollution, processing upper watershed inputs in such a way that these inputs do not extend downstream to the extent that they influence the patterns observed on the beach.

1.1 2003-2004 Sampling Summary

The last comprehensive sampling and monitoring in the Topanga Creek Watershed took place in 2003-2004. At that time, several "hot spots" in the upper watershed were identified. Total and fecal coliform bacterial exceedances were associated with storm events when tested at the Bridge on Topanga Canyon Blvd. (3600m), which is located approximately halfway between the town and the ocean (Figure 2-1). Enterococcus limits were exceeded for 50% of total storm sampling events, and the Bridge was one of the few locations where enterovirus RNA tests were positive (two events of 24) (Dagit et al 2004). Tests for *Bacteroides* were negative in all sampling events (n=12). These results need to be examined in light of known transient encampments, but one of the conclusions from the 2003-2004 study was that due to the small sample size, insufficient data was collected and additional sampling was needed in order to fully understand the patterns of pollutants in Topanga Creek as they move towards the beach.

In addition to examining the FIB conditions, other variables such as nutrients (nitrate-N, nitrite-N, orthophosphates, ammonia-N and turbidity) were also documented. Again, the pattern indicated that nutrient levels decreased as the creek flowed downstream, and hot spots identified within the upper watershed remained on the low end of typical urban conditions.

1.2 2011-2012 SIPP Sampling Summary

In a review of historical data (January 2005 – November 2011) taken by the City of Los Angeles Environmental Monitoring Division and compiled by the Los Angeles County Department of Public Works an unusual pattern of bacterial exceedances occurring at Topanga Beach well into the dry season (as late as mid July) was noted. When these data were compared to creek flow data collected by the County at the same time as the bacterial data, it was apparent that bacterial exceedances correlated strongly with breaches in the Topanga Creek Lagoon (Figure 1-1). The Topanga Lagoon discharges episodically into the ocean as late as July. This correlation between Lagoon discharges and high FIB values in ocean water samples strongly suggested that Topanga Lagoon was the primary source of high FIB levels in the surf zone.

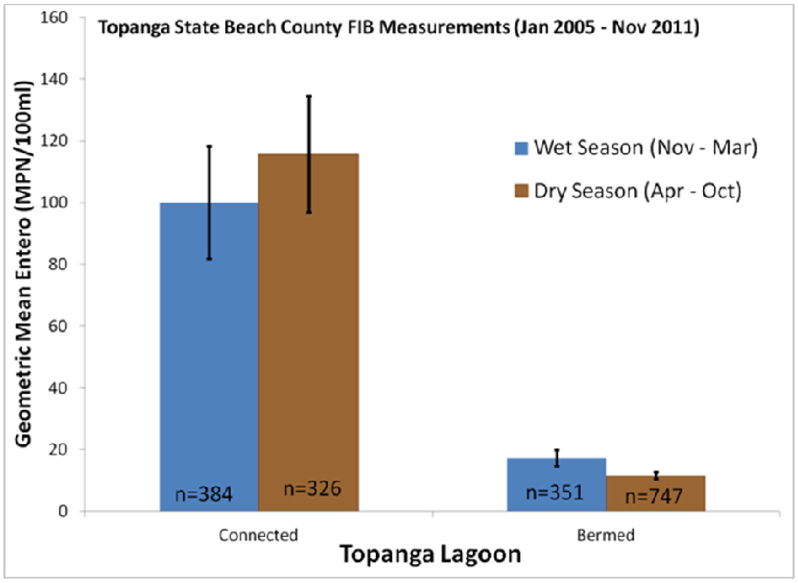

Figure 1-1 Geometric mean of Enterococcus (MPN/100mL) connected and bermed conditions for wet and dry seasons between January 2005 – November 2011.

Based on this historical analysis and the identification of the lagoon as an important source of FIB to the ocean, the UCLA SIPP team began a microbial source tracking study of those areas in October 2011. This effort began with a full watershed snapshot in October 2011 and continued through the summer of 2014. “Hot spots” identified with this snapshot were further analyzed with additional sampling and source associated markers were used to identify potential sources of fecal contamination to the watershed.

A “first flush” storm event occurred on 5 October 2011. Volunteers from the RCDSMM and UCLA collected representative water samples throughout the upper watershed downstream to the ocean at locations previously sampled in 2003-2004. Preliminary results reflected a pattern similar to that observed in the earlier study.

Results from the 2011 first flush sampling event indicated high bacterial levels throughout the watershed and, in most cases, samples were positive for the human-associated marker. Subsequent sampling events identified at least four “hot spots”. These were Entrado/Highvale Road (not re-verified in 2012 due to lack of flow), Behind Abuelita’s in town, Mile Marker 2.02 Bridge, and the Lagoon. The sampling effort of 2012 identified a hot spot of high ENT levels and related human-associated marker in the town region of the Topanga watershed. To better understand the nature and extent of this hot spot, samples were taken three times over two weeks in an attempt to bracket in the source (Figure 1-2 and Figure 1-3).

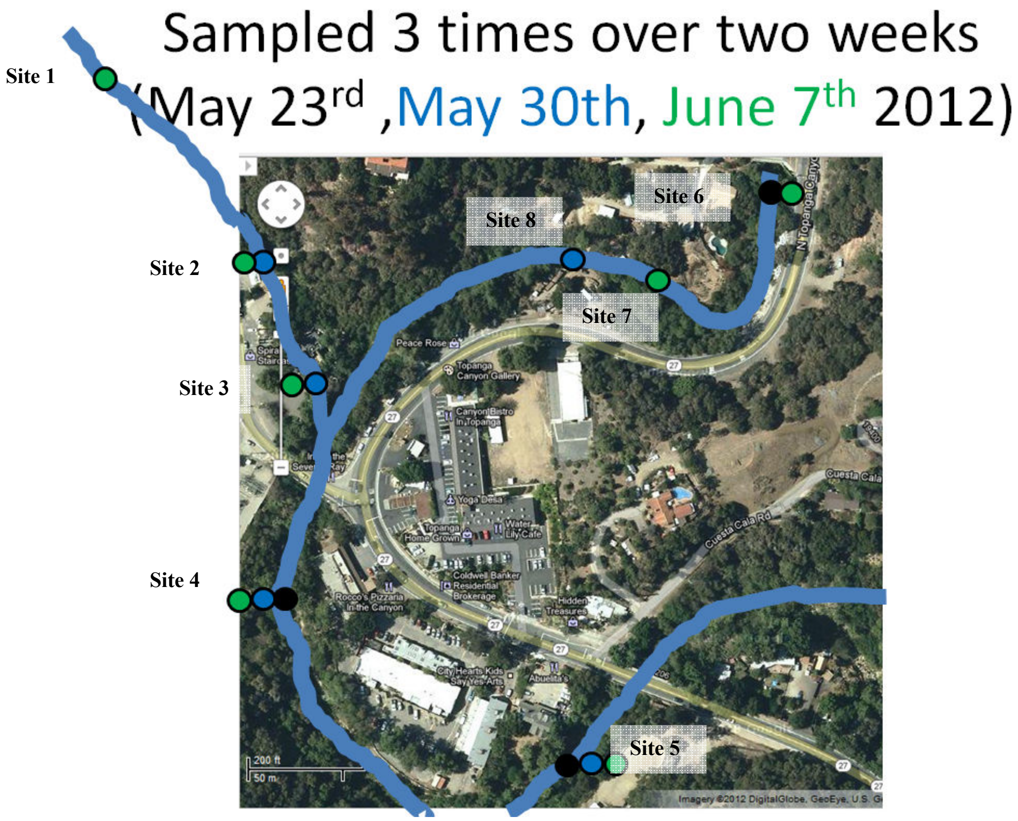

Figure 1-2 Locations of hot spot sampling taken three times over two weeks trying to locate source of large ENT levels originally detected at site 5 (Behind Abuelita's; BA).

The intensive sampling indicated that there was a source of FIB in both the main stem of the creek and the Old Topanga tributary. The main stem source did not extend above the School Road crossing, while the Old Topanga source was not definitively bracketed as exceedance levels were found at the northernmost site sampled (Backbone Trail Crossing). These sample were further analyzed for human, dog, and horse-associated markers (Table 1.1). Horse-associated marker was not detected at any of the sites sampled. High levels of human marker were detected along the Old Topanga Creek stem near the large power transformer box in addition to high levels of dog marker detected at the Inn of the Seventh Ray site. These sources may explain the concurrent hits of human and dog markers at the Post Office site. However, samples were not positive for either the human or dog marker at the Behind Abuelita's site (Figure 1-3).

The watershed sampling efforts in 2012 also expanded our understanding of the reduction in FIB levels within the Narrows, occurring between the confluence of Dix Creek with Topanga Creek at Owl Falls (6500 meters upstream from the ocean across from Jalan Jalan) and the Scratchy Trail access point (4800 meters upstream from the ocean and located near mile marker 3.75), in an area with little human development,

Sites along the main stem did not show markers except for one hit for BacHum at a level too low to quantify at the School Road site (Table 1-1). High levels of human marker were detected along the Old Topanga Creek stem near the large power transformer box in addition to high levels of dog marker detected at the Inn of the Seventh Ray site. These sources may explain the concurrent hits of human and dog markers at the Post Office site but either these sources were too diffuse to detect at Behind Abuelita's (BA) or another animal is the source of FIB seen at Behind Abuelita's (Figure 1-3).

Table 1-1 Results of hot spot sampling three times over two weeks in the summer of 2012. Map numbers correspond with sites labeled in Figure 1-2. ND indicates maker not detected, D indicates marker detected but at a level too low to quantify.

		ENT			HF183			BacHum			Dog		
Site	Map #	5/23	5/30	6/7	5/23	5/30	6/7	5/23	5/30	6/7	5/23	5/30	6/7
Backbone Trail	1			135			*			*			ND
	2		275	414		2400	*		4700	*			ND
	3		393	185		ND	*		D	*			*
School Road	6	52	65	30	ND	ND	*	ND	D	*	ND	ND	ND
	7			30			*			*			ND
	8		780			ND			ND			ND	
Post Office	4	256	223	146	8	9	*	50	ND	*	590	135	ND
Behind Abuelita's	5	233	132	63	ND	ND	*	ND	ND	*	ND	220	*

* sample taken but not yet analyzed.

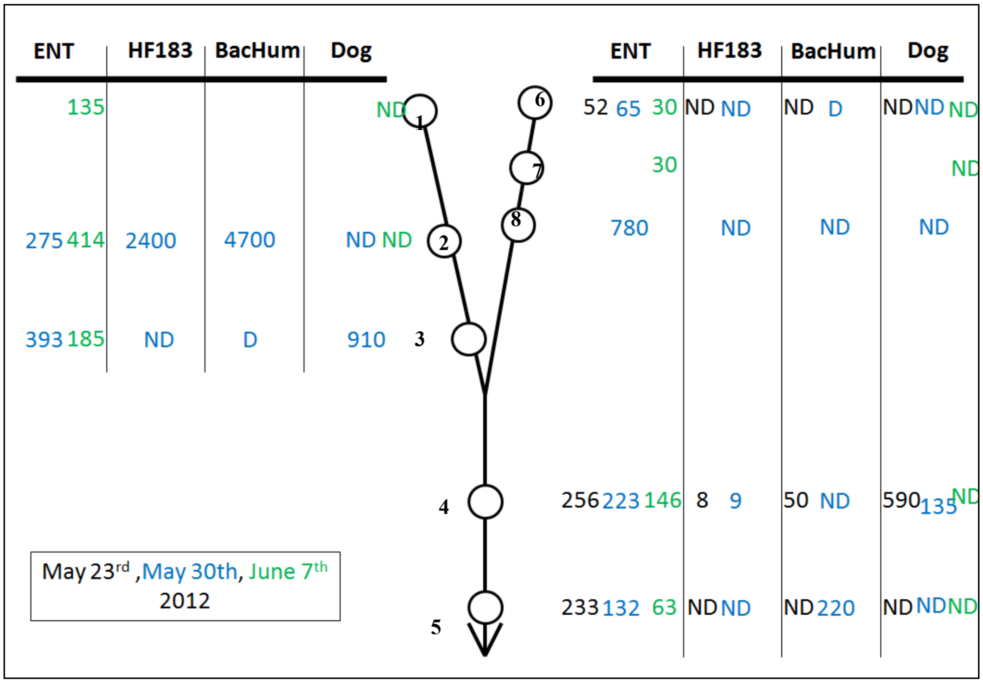

Figure 1-3 Results of hot spot sampling three times over two weeks.
Abstracted site map is shown in the middle of the figure with corresponding ENT or marker values shown (horse marker not shown because all results returned not detected (ND)). Color indicates date of sample with black 5/23/12, blue 5/30/2012, and green 6/7/2012.

1.3 Additional On-going Studies in Topanga Creek

Good water quality is essential to supporting populations of endangered species in the region, including the southern steelhead trout (*Oncorhynchus mykiss*). Topanga and Malibu Creeks are the only places where southern steelhead trout are still consistently present in the Santa Monica Bay. In 2006, there was a die-off of trout in Malibu, while those in Topanga remained healthy. The reason for this die-of remains unclear. Since 2009, the RCDSMM has deployed water quality monitoring sondes in Malibu, and in 2010, were able to compare the conditions in Malibu with those in Topanga. Those results are presented in a report on the status of steelhead in the Santa Monica Bay (Dagit and Krug 2011).

1.4 Sampling Plan 2012-2014

In December 2012, a two year tiered effort providing comprehensive sampling of the Topanga watershed was initiated. The Topanga study is a cooperative endeavor between the RCDSMM, the Jay Lab at UCLA (this lab was one of five core labs that participated in the state-funded Source Identification Protocol Project (SIPP) run by SCCWRP), the Fuhrman lab at USC, and the trained volunteers of the Topanga Creek Stream Team. Topanga Underground and BioSolutions, Inc. provided the septic tank tracing and testing information.

Building on the data collected by the SIPP MST study, this work provides the County with a better understanding of how and why exceedances occur at Topanga Beach.

A Technical Advisory Committee (TAC) was convened in December 2012 to provide oversight and assist in fine-tuning the sampling design and analysis. The TAC is comprised of stakeholder representatives including Los Angeles County Departments of Beaches and Harbors, Public Health, Public Works and the Third District Supervisorial representatives, as well as scientists from the Southern California Coastal Water Research Project (SCCWRP), California Department of Parks and Recreation, Caltrans, Regional Water Quality Control Board, University of California, Los Angeles (UCLA), BioSolutions, Topanga Underground, and RCDSMM. In addition, the proposed SIPP-related microbial source tracking (MST) efforts were evaluated and approved by the other three core labs involved in the project: the Southern California Coastal Water Research Project (SCCWRP), Alexandria Boehm's lab at Stanford, and Patricia Holden's lab at UCSB. A complete list of TAC members is found in the acknowledgements. Additional TAC meetings took place in April and October 2013, April and October 2014.

1.5 Sources of Bacteria to the Beach

Sources can be divided into two categories, lower watershed sources and upper watershed sources that travel to the beach via the main stem of the creek.

1.5.1 Potential Lower Watershed Sources Examined

Septic systems along Pacific Coast Highway in Topanga State Park. The systems at Cholada's, Ranch Motel Ranger residence, Reel Inn, Malibu Feed Bin, and Rosenthal Winery are being pumped weekly or more as needed in compliance with the contracts administered by the California Department of Parks and Recreation. They are all older systems and are disconnected from leach fields or seepage pits, these tanks were tested during summer 2013 to examined the conditions of outlet T's to ensure that they have been sealed to prevent any discharge into abandoned drainfields. The holding capacity and pumping protocol of these tanks was also examined. Results are included in Chapter 6 and Appendix H.

Beaches and Harbors restrooms and lifeguard station. While a stand-alone treatment facility exists at this site, it was evaluated and listed as a potential source in the event of a malfunction and/or maintenance issues.

Wildlife, including gulls and other seabirds, deer, coyotes. Although it is only 1.8 acres, the remnant lagoon at the mouth of Topanga Creek is consistently used by roosting and foraging waterfowl. Bacterial contributions from bird feces have been identified as the source of FIB in other coastal lagoons, such as Cowell Beach in Santa Cruz (Russell et al. 2013) and a beach in Racine, WA (Converse et al. 2012).

1.5.2 Potential Upper Watershed Sources Moving Downstream Through the Creek to the Lagoon Examined

Homes on septic systems throughout watershed. While many homes in Topanga were built in the 1920's and 1930's resulting in old septic systems, the County Public Health Department has a program in place to monitor existing systems. Approximately 200 of the 3,000 homes in the watershed are located directly adjacent to the creek.

Transient encampments. Several locations throughout the watershed are known to house transient populations. While encampments are dispersed whenever identified, it is possible that new encampments exist.

Horses. There are several establishments housing large numbers of horses, and many residents throughout the watershed have one or two horses on fairly small parcels. Horses are ridden in open land throughout the watershed, resulting in a potentially diffuse bacterial source. Horse feces at barns are sometimes composted and these piles could also serve as a bacterial source.

Dogs. Fecal matter from the many household dogs would be a potential diffuse source of bacteria in the watershed.

Wildlife including coyotes, deer and birds. 70% of the watershed is undeveloped; thus, the watershed is home to coyotes, deer, native pond turtles, mountain lions, and other species.

1.6 Hypotheses Tested

1) Upper watershed sources of FIB are not conveyed to the beach via the creek.
2) Concentrations of FIB and/or pathogens and nutrients decrease as the creek flows downstream as measured between the MM 2.02 bridge and the lagoon. Benthic macroinvertebrate community species diversity, sensitivity, and abundance increase as the creek flows downstream from the town.
3) FIB and/or pathogens are not leaking from faulty septic systems in the lower watershed along Pacific Coast Highway in Topanga State Park or from the County Lifeguard facility.
4) Lower watershed and/or lagoon sources of FIB (human and non-human inputs such as gull, dog, etc.) are correlated with exceedances at Topanga Beach.

1.7 References Cited

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Russell, T. L., L. M. Sassoubre, D. Want, S. Masuda, H.Chen, C. Soetjipto, A. Hassaballah, and A. B. Boehm. 2013. A coupled modeling and molecular biology approach to microbial source tracking at Cowell Beach, Santa Cruz, CA, United States. *Environmental Sci. Technol.* Online only

2 Study Sites 2012-2014

The location of sampling sites (Table 2-1) includes County funded sites in the ocean and Topanga Lagoon, moving upstream as far as the Topanga Bridge (3600 m), which is located halfway between the ocean and the town of Topanga. Locations in Topanga Creek have been mapped and are identified by both pool name and meters upstream from starting place at the Pacific Coast Highway Bridge (Table 2-1). In addition, UCLA is also sampling further upstream using SIPP funding. Detailed information on the standard operating procedures and Quality Assurance/Quality Control protocols are found in Appendix G. Using the approaches described below, we have endeavored to test each hypothesis and identify both the locations of sources of FIB and/or pathogens, as well as identify the host species.

2.1 Sampling Locations

Sample sites were chosen in order to gain a comprehensive understanding of water quality within the Topanga watershed. Sites with high levels of FIB were retained, while additional sites were occasionally added in order to more effectively identify source of elevated FIB, or removed if patterns of FIB levels at that site varied little with sites directly above and below. A few locations above Owl Falls were sampled on several occasions as part of the SIPP study in 2013. However, due to a lack of flow in the upper watershed, the primary focus of the effort was downstream of the total upper watershed inputs (Table 2-1). All sites were sampled at the first flush rain events (17 Nov. 2012, 24 January and 8 March 2013, and 27 February 2014).

Photos were taken at each site to document specific conditions for that sampling event. These photodocumentation summaries are found in Appendix B.

Table 2-1 Sampling Locations (Coordinate System: UTM, Zone 11N). FF= first flush rain event.

Site Name	**Easting (m)**	**Northing (m)**	**Elevation (ft)**	**Number Samples Wet Season**	**Number Samples Dry Season**
Beach Upcoast -175m (BU)	353726	3767515	0	2/mo + FF	1/mo
Beach Outlet- 0 m (BO)	353896	3767506	0	2/mo + FF	1/mo
Lagoon Outlet-1m (LO)	353872	3767529	0	2/mo + FF	1/mo
Lifeguard Station Beach (LG)	353968	3767553	0	2/mo + FF	1/mo
Topanga Lagoon-25m (TL)	353887	3767573	0	2/mo + FF	1/mo
PCH Bridge - 35m (HB)	353868	3767649	0	2/mo + FF	1/mo
Lifeguard Station Septic (LS)	353994	3767655	0	1/mo	1/mo
Snake Pit – 300 m (SP)	354015	3767841	0	2/mo + FF	1/mo
Brookside Drive – 1700 m (BR)	354075	3768713	0	2/mo + FF	1/mo
Topanga Bridge – 3600 m (TB)	353522	3770391	200	2/mo + FF	1/mo
SIPP SITES					
Scratchy Trail – 4800 m (ST)	353518	3771500	500	2/mo + FF	1/mo
Owl Falls – 6500 m (OF)	352673	3772373	700	2/mo + FF	1/mo
Falls Drive (FD)	352535	3772259	750	occasional	
Behind Abuelita's (BA)	351570	3772891	700	occasional	

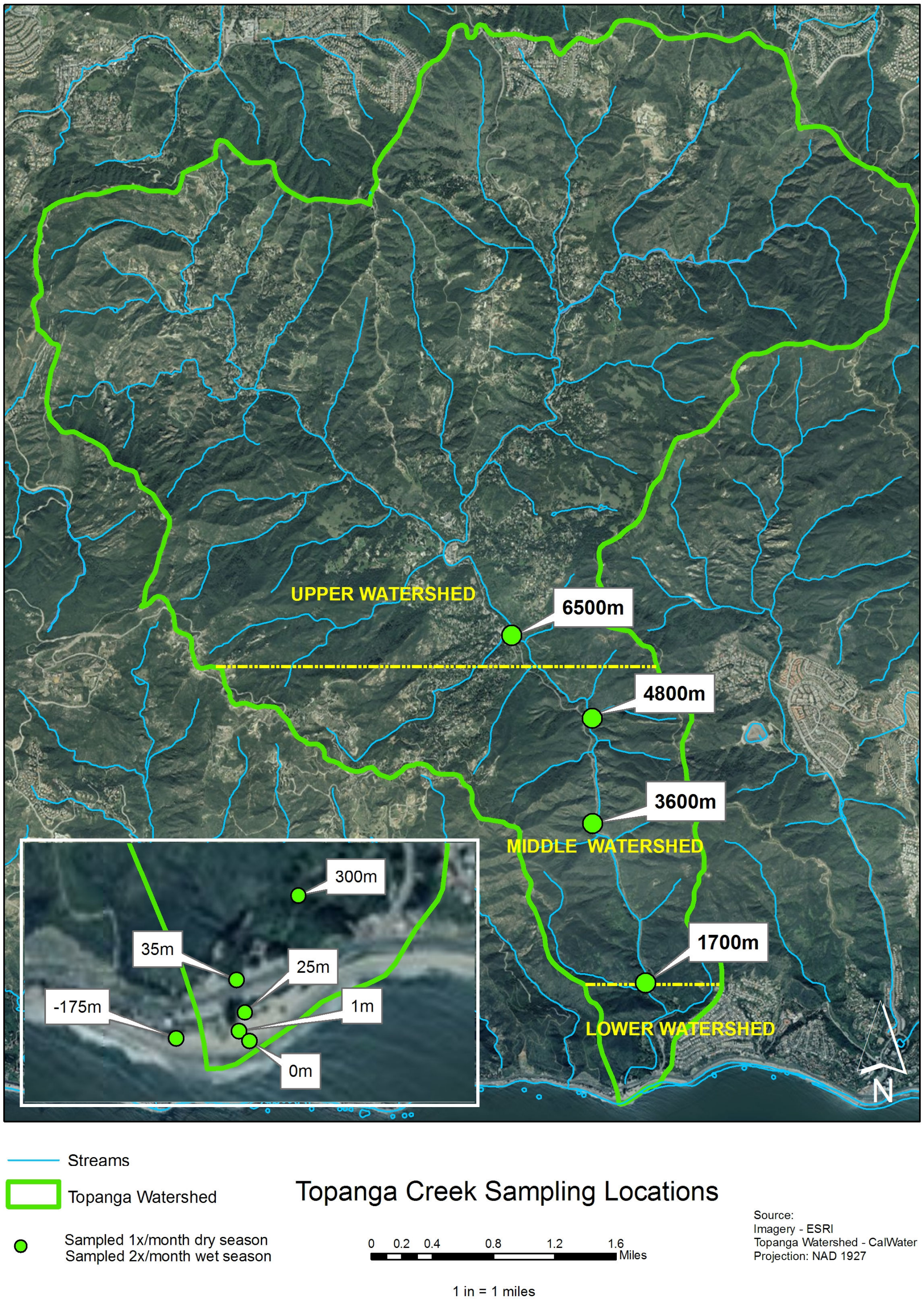


Figure 2-1 Map of the 2012-2014 (and 2003-04) Topanga Creek Watershed County funded sampling locations.

3 Microbial Source Identification Study

3.1 Background

Topanga Beach, California is frequently listed as one of the most impacted beaches in the state of California (Heal the Bay 2013) based on fecal indicator bacteria (FIB) levels, despite numerous projects within the lower watershed intended to improve water quality. Ranked 9th most polluted California beach in 2006, 4th in 2010-11, and 10th in 2011-12, Topanga Beach has FIB exceedances well into the summer season, but the sources of FIB to the ocean have been unknown. Potential sources of fecal contamination to the watershed include malfunctioning septic systems, transient populations, horses, dogs, gulls and other wildlife specific to the region. Topanga Creek and lagoon may also be potential sources of FIB to the surfzone; microbial contamination may be transported from the upper watershed via the creek to the lagoon and beach. Studies have also shown beach sand and sediments can harbor bacteria and serve as a source of FIB to the water column (Ishii et al. 2007, Yamahara et al. 2009).

A two-year microbial source tracking (MST) study was initiated in the Topanga Creek watershed that measured FIB levels and also utilized culture-independent molecular markers for detection of host-associated fecal contamination. Unlike FIB, which can originate from multiple hosts, MST methods can help identify unique sources of fecal pollution through use of host-associated markers that allow for identification of the likely original host of fecal pollution to environmental waters (Harwood et al. 2013, Boehm et al. 2013).

Hypotheses and Objectives

This study investigated sources of FIB to the Topanga Creek watershed and reports on the applicability of using MST technology. A combination of approaches including snapshot surveys, long-term monitoring during wet (winter) and dry (recreational) seasons, and the use of a suite of markers at all sites was utilized to identify likely sources of FIB. We hypothesized that:

1) Lagoon discharge negatively impacts water quality at Topanga Beach
2) Concentrations of FIB and/or host-associated markers decrease as the creek flows downstream towards the lagoon; therefore, creek inputs do not affect surfzone FIB during both normal and drought conditions.
3) Spatial and temporal patterns of FIB and host-associated markers exist between sites in the lower watershed
4) Lower watershed and/or lagoon sources of FIB (human and non-human inputs such as gull, dog, etc.) are correlated with exceedances at Topanga Beach.

A fifth hypothesis concerning the use of a rapid viability-based method (IMS/ATP) and a sixth hypothesis concerning differential decay rates for FIB and markers in sediment were also explored and results are included in Appendix J.

3.2 Methods

Field Site- Topanga Creek Watershed

Topanga Beach receives over 750,000 annual visitors and suffers from poor water quality. Due to the Mediterranean climate, this region experiences a dry recreation season (April – October) and wet season (November – March), with typical rainfall averaging 20 inches a year. However, rainfall during the course of this study was below average levels. Topanga Creek watershed (approximately 47 km^2) is 70% undeveloped (GeoPentech, 2006) and includes a creek and lagoon system. Topanga Creek drains the upper watershed and cumulates in Topanga Lagoon, a dynamic lagoon system that breaches and berms throughout the year, contributing variable flow to Topanga Beach. This site is critically important to several sensitive and endangered species including the steelhead trout, California newts and multiple species of frogs (Western toads, California tree frogs and Pacific frogs) (Dagit et al. 2007, Dagit et al. 2003). For additional information regarding site details including location and site descriptions please see Section 2 of this report.

Fecal Indicator Bacteria (FIB) Analysis

Water samples collected from Topanga watershed were analyzed for fecal indication bacteria (FIB) levels and host-associated molecular markers for human, dog, horse, and gull. To obtain FIB concentrations, Total Coliform (TC), *Escherichia coli* (EC), and enterococci (ENT) were measured with Colilert-18^{TM} and Enterolert^{TM} (IDEXX, Westbrook ME) reagents and protocols to determine the most probable number (MPN) of cells per 100 ml sample. Samples were analyzed at a 1:10 dilution as recommended by the manufacturer, or a 1:100 dilution on an as needed basis. The limit of detection (LOD) for these assays is 10 MPN/100ml and any sample below the limit of detection was assigned a value of 5 MPN/100ml for analysis. Samples above the range of quantification (ROQ) were assigned the maximum value depending on the dilution used. For example, samples with observed concentrations of >24196 MPN/100ml were set to 24196 MPN/100ml.

Host-associated Marker Analysis

Two human-associated markers were measured using the HF183 Taqman (HF) (Haugland et al. 2010) and the BacHum Taqman (BH) assays (Kildare et al. 2007). Results from year one showed strong correlation between HF and BH markers. Therefore, BH was used only to confirm a human signal in samples positive for the HF183 marker (n=42) during the second year of the study. Samples were also analyzed for animal sources with three additional markers. The Gull2 Taqman assay (Gull) (Lu et al. 2008) was used to measure gull-associated marker and the DogBac Taqman assay (Dog) (Dick et al. 2005) was used to measure dog-associated marker. A conventional endpoint PCR assay, HoF597 (Horse), was used to detect fecal inputs associated with horse waste. Marker selection was based on a previous multi-laboratory comparison study (Boehm et al. 2013). Primers and conditions used for each qPCR assay are listed in Table 3-1.

For the measurement of HF183, BH, Dog and Gull gene copies per 100 ml, sample water was filtered through 47 mm, 0.4 µm pore size, HTTP polycarbonate filters (EMD Millipore, Billerica, MA) in triplicate. Each filter was placed in an individual two ml polypropylene screw cap tube, containing 0.3 g, 212 – 300 µm (50 – 70 U.S. sieve) acid washed glass beads (Sigma-Aldrich, St. Louis, MO) and stored at -80°C until DNA extraction. DNA extraction was conducted with the DNA-EZ ST1 Extraction Kit (GeneRite, North Brunswick NJ) following the manufacturer's protocol. Eluted DNA samples were stored at -20°C until analysis of molecular host-associated markers with qPCR.

Table 3-1. List of host-associated molecular markers used in Source ID study within Topanga Watershed.

Name	Source	Type	Target	Forward Primer / Reverse Primer	Probe/Dye	Reference
HF183 Taq	Human	qPCR	*Bacteroides* 16S	ATCATGAGTTCACATGTCCG / CGTAGGAGTTTGGACCGTGT	FAM-CTGAGAGGAAGGTCCCCCACATTGGA-TAMRA	Haugland et al., 2010
BacHum	Human	qPCR	*Bacteroides 16S*	TGAGTTCACATGTCCGCATGA/ CGTTACCCCGCCTACTATCTAATG	FAM-CTGAGAGGAAGGTCCCCCACATTGGA-TAMRA	Kildare et al., 2007
Gull2 Taq	Gull	qPCR	*Catellicoccus marimammalium*	TGCATCGACCTAAAGTTTTGAG/ GTCAAAGAGCGAGCAGTTACTA	FAM-CTGAGAGGGTGATCGGCCACATTGGGACT-BHQ1	Shibata et al., 2010
DogBact	Dog	qPCR	*Bacteroidales spp.*	CGC TTG TAT GTA CCG GTA CG CAA TCG GAG TTC TTC GTG	FAM-ATTCGTGGTGTAGCGGTGAAATGCTTAG-BHQ1	Sinigalliano et al., 2012
HoF597	Horse	Endpoint	*Bacteroidales spp.*	CCA GCC GTA AAA TAG TCG G CAA TCG GAG TTC TTC GTG	N/A	Dick et al., 2009

FIB and Marker Analysis

Geometric means and standard deviation of the geometric mean were calculated for FIB and host-associated markers and are shown in Tables 3-3 and 3-4 and Figures 3-1, 3-2, 3-4 to 3-7 for creek, lagoon, and ocean sites. The number of samples analyzed for each site is listed below (Table 3-2).

Table 3-2. Number of samples used to calculate geometric mean for FIB and markers at creek, lagoon, and ocean sites: OF (Owl Falls), ST (Scratchy Trail), TB (Topanga Bridge), BR (Brookside Drive), SP (Snake Pit), BU (Beach Upcoast), BO (Beach Outlet), LG (Lifeguard Station), HB (Hwy 1 Bridge), TL (Topanga Lagoon), and LO (Lagoon Outlet). Data are entered for each site and indicator as follows: n for total site/ n for winter season/ n for recreational season for each site.

	Site	**TC**	**EC**	**ENT**	**HF**	**BH**	**Gull**	**Dog**
Creek	**OF**	22/7/15	22/7/15	22/7/15	22/7/15	15/5/10	22/7/15	21/6/15
	ST	22/9/13	22/9/13	22/9/13	22/9/13	12/4/8	22/9/13	21/8/13
	TB	32/18/14	32/18/14	32/18/14	33/18/15	18/10/8	33/18/15	33/18/15
	BR	26/15/11	26/15/11	26/15/11	25/15/10	13/7/6	25/15/10	24/14/10
	SP	29/12/17	29/12/17	29/12/17	27/12/15	19/10/9	26/11/15	27/12/15
Ocean	**BU**	34/20/14	34/20/14	34/20/14	33/20/13	19/12/7	34/20/14	34/20/14
	BO	38/21/17	39/21/18	38/21/17	37/20/17	23/15/8	38/21/17	38/21/17
	LG	25/12/13	25/12/13	25/12/13	25/12/13	9/4/5	25/12/13	24/12/12
Lagoon	**HB**	35/19/16	35/19/16	36/19/17	36/18/18	19/11/8	35/17/18	36/18/18
	TL	37/21/16	37/21/16	37/21/16	36/20/16	24/14/10	37/21/16	36/20/16
	LO	15/10/5	15/10/5	15/10/5	15/10/5	15/10/5	15/10/5	15/10/5

Host-associated Marker and FIB QA/QC

The qPCR reaction mixture consisted of 2 µL of DNA template combined with the appropriate primer probe sets and thermal cycling conditions, depending on the assay used. Samples and calibration standards were run in triplicate. A five-point standard calibration curve was run alongside samples on each well plate. Standard curves had efficiencies between 90 - 110% and R^2> 0.99. Filter blanks, consisting of 50 mL of PBS passed through the polycarbonate filter, were also generated with each set of processed samples. Negative controls (no template controls) and filter blanks and extraction blanks were included to ensure contamination of samples did not occur during either the filtration or extraction processes, or while plating samples in the 96 well plate during the qPCR procedure. In addition, FIB values recorded in this study were compared with FIB values measured during regular water quality monitoring conducted by the county Public Health department. A strong linear relationship between both data sets were observed for measured TC and EC values (R^2 =0.7).

Dog-associated marker survey

A survey of FIB and dog marker concentrations in water and sand was conducted at four beaches in May 2014, with the goal of comparing dog marker levels from Topanga to both references beaches and a dog beach. Water and sediment samples were collected during morning hours (6 AM – 11:30 AM) on May 2, 2014 from Topanga (n=24), Malibu (n=4) and Dockweiler (n=4), both of which served as controls as they have minimal dog activity, and Rosie’s Dog Beach in Long Beach (n=16).

Marine sites were sampled using autoclaved 125 mL Nalgene bottles that were submerged ankle deep in ocean waters on an incoming wave. The top one cm of sediment was collected with sterile 50 ml Falcon tubes by sliding the tube across the surface; 10 composite scrapes collected within a one square meter made up the sediment surface samples for both wet and dry sediment. Wet sediment was collected within the tidal wash zone. Approximately 4 m inland of that location, a dry surface sediment sample and a depth sample was also collected. Trowels cleaned with ethanol were used to dig six inches below the surface of the sand; a clean falcon tube was then used to collect sand at this depth. Samples were processed on-site for TC, EC and ENT, with the help of Topanga Elementary School and Topanga Mountain School as part of the community involvement and outreach effort. Extra sediment and water samples were then transported on ice, to the lab, within six hours of collection and filtered/preserved for DNA extraction at UCLA. Samples were stored at -80°C until further processing for qPCR.

Analysis of isolates with 16S rRNA Sequencing

Enterococcus (ENT) isolates were characterized in order to help determine whether ENT originating from water samples collected at Topanga Lagoon and ocean sites are predominately fecal or environmental-associated species . *E. faecalis* and *E. faecium* are the most prevalent ENT species in human feces and can be distinguished from other species (e.g. *E.casseliflavus* and *E.mundtii*) that are more often associated with plants and soil (Byappanahalli et al. 2012). Bacterial isolates were selected and isolated from lagoon and ocean sites after three consecutive sampling trips on July 2, 2014, July 15, 2014, and August 11, 2014 as well as from a subset of samples collected during summer 2013. Bacterial isolates were cultured with mEI media following the membrane filtration USEPA Method 1600 and with the Enterolert^{TM} defined substrate test (IDEXX, Westbrook ME). For USEPA Method 1600, presumptive enterococci isolates (identified with a blue halo) were selected from each plate and subcultured onto Todd Hewitt plates. For Enterolert, 70% ethanol was used to disinfect the back of the Quanti-Tray and media was removed from fluorescing wells with a sterile 1 ml syringe following methods used for isolation in Ferguson et al. 2013. Bacterial isolates were purified from both Enterolert and mEI because these two culture-based methods can differ due to substrate differences and/or differences in selectivity of the two methods (Ferguson et al. 2013).

Following purification of bacterial isolates, DNA was extracted according to Shanks et al. (2011). Universal primers were used to amplify partial 16S rRNA genes by PCR. The MoBio 12500-50 UltraClean PCR Clean-Up kit was used according to manufacturer's guidelines for DNA purification. Further processing and sequencing of the 16S gene was performed at UCLA Genotyping and Sequencing Core (GenoSeq, Los Angeles, CA) with the Biosystems 3730 Capillary DNA Analyzer, using capillary technology. Sequences were realigned with CLUSTALW (SDSC WorkBench 3.2) and blasted against the NCBI nucleotide database (NCBI-BLAST).

Horse PCR Sensitivity Analysis

To investigate whether negative samples analyzed from Topanga were a factor of poor LOD, an experiment was conducted to ascertain if the horse LOD varies depending on water matrix. HoF597 (horse marker) LOD was determined at our field site in creek (CW), lagoon (LW) and marine (MW) waters.

Fresh fecal matter from 12 individual horses was collected in the summer of 2013. Samples were collected into falcon tubes using sterile spatulas from fresh deposits, stored on ice and transported back to the lab for analysis. Approximately one gram of feces per horse was combined to make a composite sample of 12g, which was then diluted in 50mL of artificial freshwater (AW) (for AW recipe see Riedel et al., 2014) to create a final horse feces slurry concentration of 0.24g/mL. This procedure was repeated and new slurries created by spiking composite samples into the different water types: creek, lagoon or marine. A 1:100 dilution was then made from the initial slurry type (AW, CW, LW and MW) and used as the starting concentration for analysis (.00024g/mL).

3.3 Results

Comparison of geomeans for winter and recreational seasons for FIB and host-associated markers

Seasonal and weather effects on FIB/marker concentrations were examined by grouping data collected in the winter (November - March) versus recreational (April - October) season, or during active rainfall (raining) versus dry event (not-raining) samples.

For the overall study, when geometric means of the watershed FIB and marker values from winter season were compared to the geometric means of the recreational season, the winter season samples were four to eight times higher than recreational season samples for the Gull and Dog markers (Table 3-3). However, the geomeans of the winter and recreational season values for FIB (EC, ENT, and TC) as well as the human marker were within a factor of two of each other.

Table 3-3. Winter (Nov. 1 to Mar. 31) and Recreational Season (April 1 to Oct. 31) geometric means of FIB and marker values from Oct. 5th, 2011 to Aug. 11th, 2014. Values in parentheses indicate number of data points (N). Rain data not used in this analysis.

	TC MPN/100ml	**EC** MPN/100ml	**ENT** MPN/100ml	**HF** gene copies/100ml	**BH** gene copies/100ml	**Gull** gene copies/100ml	**Dog** gene copies/100ml
Winter	613.4 (180)	47.0 (180)	46.4 (188)	18.7 (176)	58.8 (121)	1855 (176)	1229.0 (174)
Recreation	1060 (184)	35.2 (184)	69.1 (207)	21.3 (200)	56.3 (119)	488.3 (201)	171.6 (199)

Comparison of geomeans for FIB and host-associated markers during active rain and not-raining events

Several sampling events occurred during active rainfall with largest rain events occurring on 10/5/11, 11/17/12, 1/24/13, 3/8/13, 2/27/14. When geometric means of the watershed FIB and marker values of samples taken during rain were compared to the geometric means of non-rain samples, the rain samples were three to nine times higher than non-rain samples with the exception of Gull marker (Table 3-4). Geometric means for all markers and FIB were higher in samples collected during active rainfall, which is typical of other studies throughout southern California (Noble et al. 2003, Boehm et al. 2002, Surbeck et al. 2006).

Table 3-4. Geometric means of FIB and marker values for all samples collected during active rainfall versus all samples collected when not actively raining from Oct. 5th, 2011 to Aug. 11th, 2014. Values in parentheses indicate number of data points (N).

	TC MPN/100ml	**EC** MPN/100ml	**ENT** MPN/100ml	**HF** gene copies/100ml	**BH** gene copies/100ml	**Gull** gene copies/100ml	**Dog** gene copies/100ml
Raining	3340.4 (50)	361.5 (51)	278.4 (59)	69.6 (51)	324.2 (42)	1082.0 (50)	4007.1 (49)
Not Raining	808.8 (364)	40.6 (364)	61.8 (379)	20.1 (376)	57.1 (242)	910.5 (377)	430.0 (373)

Relationship between FIB levels and environmental variables

The relationship between the following physical and chemical variables (conductivity, temperature, dissolved oxygen, pH, turbidity, and nutrients) and FIB levels was compared. Temperature, conductivity, and pH levels were not correlated with FIB levels. Turbidity levels were highly correlated with ENT and EC measurement at several of the creek sites: BR (ENT R=0.76, EC R=0.96), ST (ENT R=0.99, EC R=0.99), and OF (ENT R=0.90, EC R=0.91). Nutrient levels (nitrate and phosphate) were also correlated with ENT and EC levels at the upper watershed sites: ST (R>0.75) and OF (R>0.90). Fecal sources may contain increased levels of nutrients and turbidity, which could result in the correlations seen here. At the lower watershed sites (TB, BR, and SP), nutrients and FIB levels were not correlated.

Spatial analysis along the creek of geometric means of FIB and host-associated markers

Five sites along the creek (OF, ST, TB, BR and SP) were analyzed for FIB and host-associated markers. Geometeric means of TC remained high at all sites sampled, suggesting a natural background signal of total coliform bacteria in the creek. Highest levels of all three FIB were observed just downstream of the developed portion of the watershed near the town of Topanga at Owl Falls site (6500 m). A decrease was seen immediately downstream of this site at Scratchy Trail (4800 m) for geometric means of EC and ENT. Values increased somewhat by SP (300 m), the site just upstream of Topanga Lagoon for EC (Figure 3-1).

In addition, a selection of samples from creek sites was analyzed for the horse marker. All samples analyzed, including samples from the first flush rain event during year two of the study, were negative for the horse marker (n=34). Further, the limit of detection was calculated for the horse marker assay. Using a slurry of fecal matter collected from twelve horses from the Hansen Dam Equestrian Center on September, 17th, 2013, endpoint PCR was performed on a series of ten-fold dilutions. In all waters tested, the LOD was between 0.01 and 0.1 CFUs/µL of DNA extract.

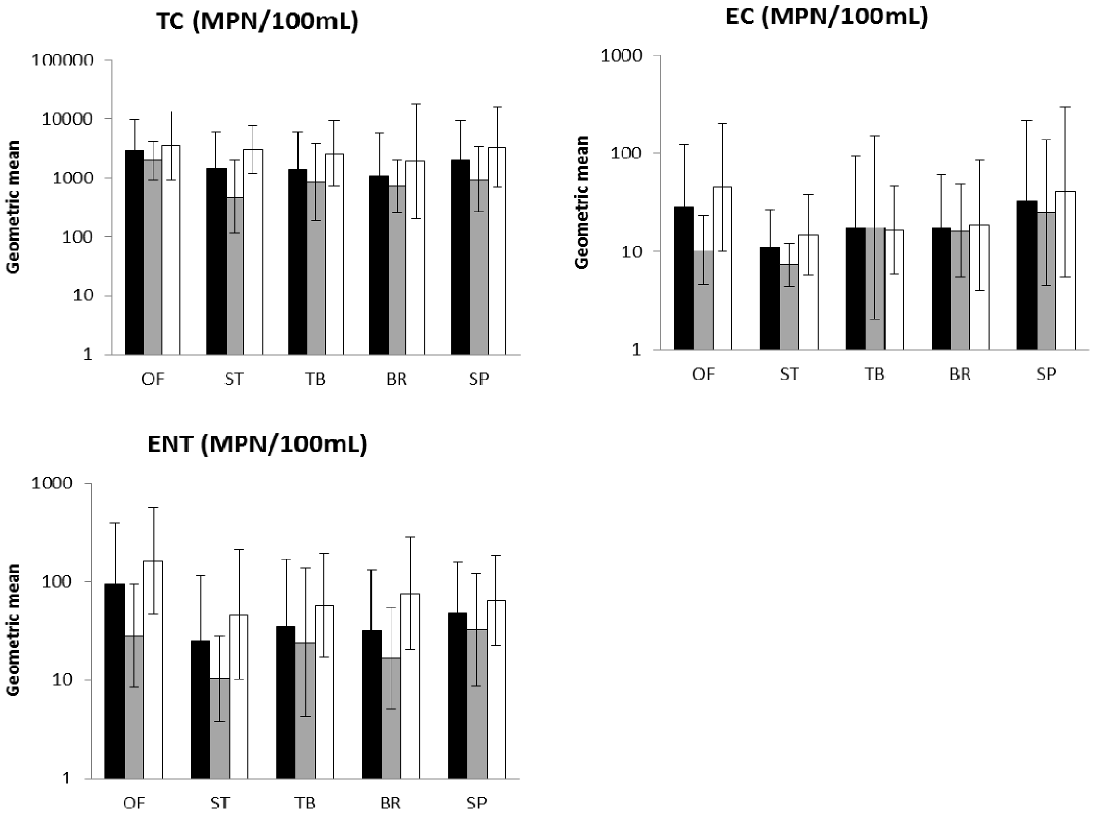


Figure 3-1. FIB values for Topanga Creek sites: Owl Falls (6500m OF), Scratchy Trail (4800m ST) Topanga Bridge (3600m TB), Brookside Dr. (1700m BR) and Snake Pit (300m SP) from 5 Oct 2011 to 11 August 2014. Note the log scale vertical axis to accommodate the large range of values and the scale range changes. The sites are ordered from north (left) to south (right). The overall geomean for each site is shown in black while gray indicates the winter season geomean and white indicates the recreational season geomean.

As with EC and ENT, the geomeans of the human- and dog-associated markers were highest at OF and decreased at the next downstream site, ST. For most of the creek, dog marker had a geomean of 100 copies/100 mL. Levels of the gull-associated marker were low throughout the creek with a geomean of approximately 100 copies/100 mL (Figure 3-2).

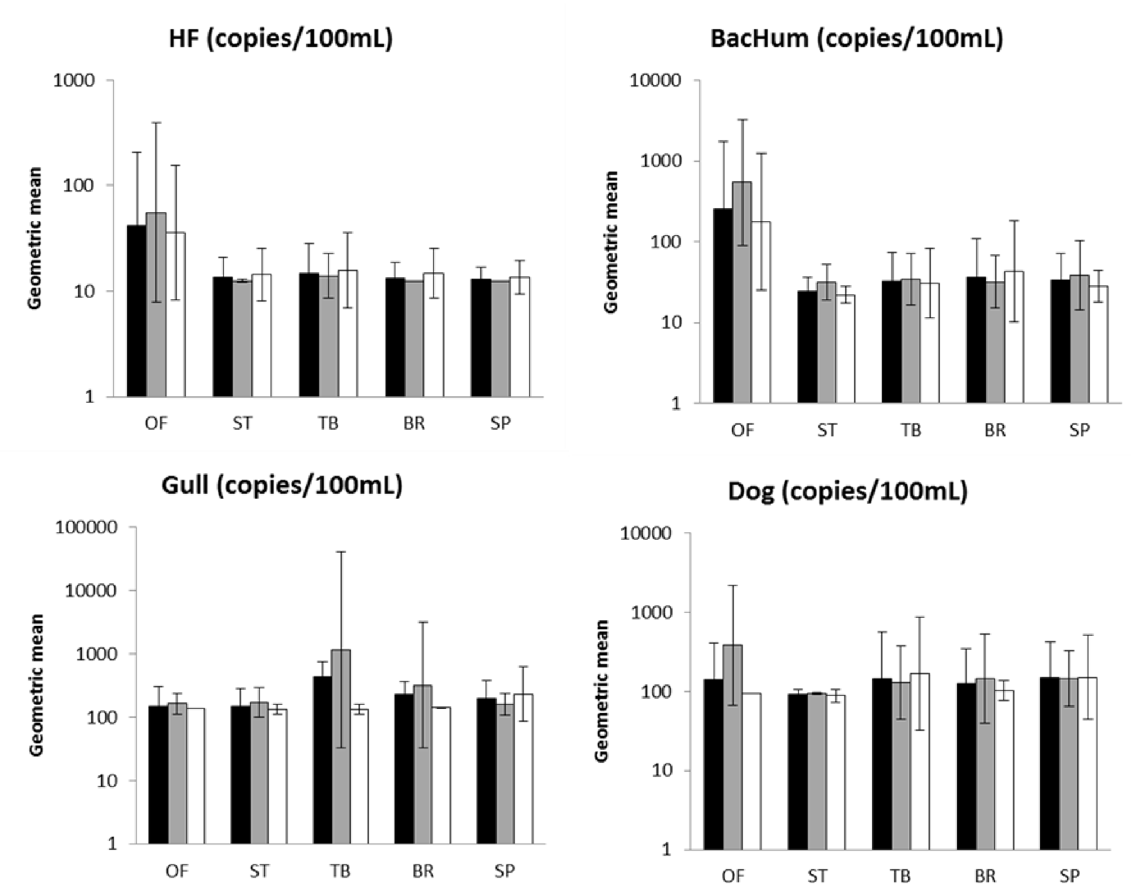


Figure 3-2. Marker values for Topanga Creek sites: Owl Falls (6500m OF), Scratchy Trail (4800m ST) Topanga Bridge (3600m TB), Brookside Dr. (1700m BR) and Snake Pit (300m SP) from 5 Oct 2011 to 11 August 2014. Note the log scale vertical axis to accommodate the large range of values and the scale range changes. The sites are ordered from north (left) to south (right). The overall geomean for each site is shown in black while gray indicates the winter season geomean and white indicates the recreational season geomean.

Analysis of Predicted Surfzone FIB From Creek Input During Drought and Normal Rainfall Conditions

In order to gauge relative impact of creek fecal inputs on surfzone water quality, predicted surfzone FIB was calculated based on creek flow and creek FIB concentrations from the current study period (2012-2014) and from historical data taken between 2003-2004. During the 2003-2004 study period Topanga received 18.71 inches of cumulative rainfall compared to 9.99 in 2013 and 6.85 so far in 2014.

In the period that was studied for this report, Topanga Lagoon and Creek acted as primarily disconnected systems, with inputs to the upper watershed decreasing prior to reaching the lower watershed. In order to speculate about potential impacts from the upper watershed on surfzone FIB during different flow regimes, dilution factors were calculated for creek inputs to the ocean. The contribution of freshwater discharge to surfzone FIB was approximated using a two end-member conductivity model, modeled after McLaughlin et al. (2007).

Conductivity at the Beach Outlet site was used as a conservative tracer to predict fraction of creek input to surfzone on days when the lagoon was connected. 100% creek was estimated based on average conductivity of all creek sites and 0% creek conductivity was estimated based on maximum conductivity at Beach Upcoast when the lagoon was not discharging. Using the end-member model, contribution of creek water to beach outlet on days when the lagoon was connected was calculated. This was then converted to a range of dilution factors for creek to ocean and related to creek flow at each time point. The relationship between dilution factor at Beach Outlet and creek flow rate was not linear, due to various mixing mechanisms, and had a logarithmic relationship ($y = -6.193\ln(x) + 11.207$, $R^2=0.85$). This relationship was then used to predict a conservative dilution factor for each sampling date based on creek flow. Creek flow data available for the 2003-2004 analysis were qualitative and ranked 1-4. These values were converted to an estimated quantitative flow measurement.

Once dilution factors had been calculated, as described above, these were applied to actual creek FIB values in order to speculate on predicted contribution of creek FIB to surfzone FIB levels, for a connected system. This analysis was speculative and assumed an open lagoon to the ocean, which would be the conservative approach. For the 2003-2004 season, when FIB and flow data from Topanga Bridge were used, creek FIB could have potentially led to exceedances in the surfzone on two out of 14 dates sampled. One of these dates was first flush (10/19/2004) and the other date (9/14/2004) had extremely elevated ENT (ENT>1500MPN/100 mls). When FIB and flow levels were applied from Falls Drive, predicted surfzone ENT levels were in exceedance only during the first flush event.

For the 2012-2014 season, when FIB and flow data from Topanga Bridge were used, this analysis predicted that creek FIB could have led to one exceedance of surfzone FIB levels, this date corresponded to the 2014 first flush event, and two exceedance events if Owl Falls flow and FIB data were applied, with one of these two events corresponding to the 2014 first flush event. Based on this analysis, it does not appear that creek FIB contribute significantly to elevated surfzone FIB, except during events of elevated flow and elevated FIB, such as a first flush event (Figure 3-3). Further, analysis of FIB data from 2003-2004 confirms that this trend may carry over to rainier years, which experience increased flow and connectivity between upper and lower watershed sites.

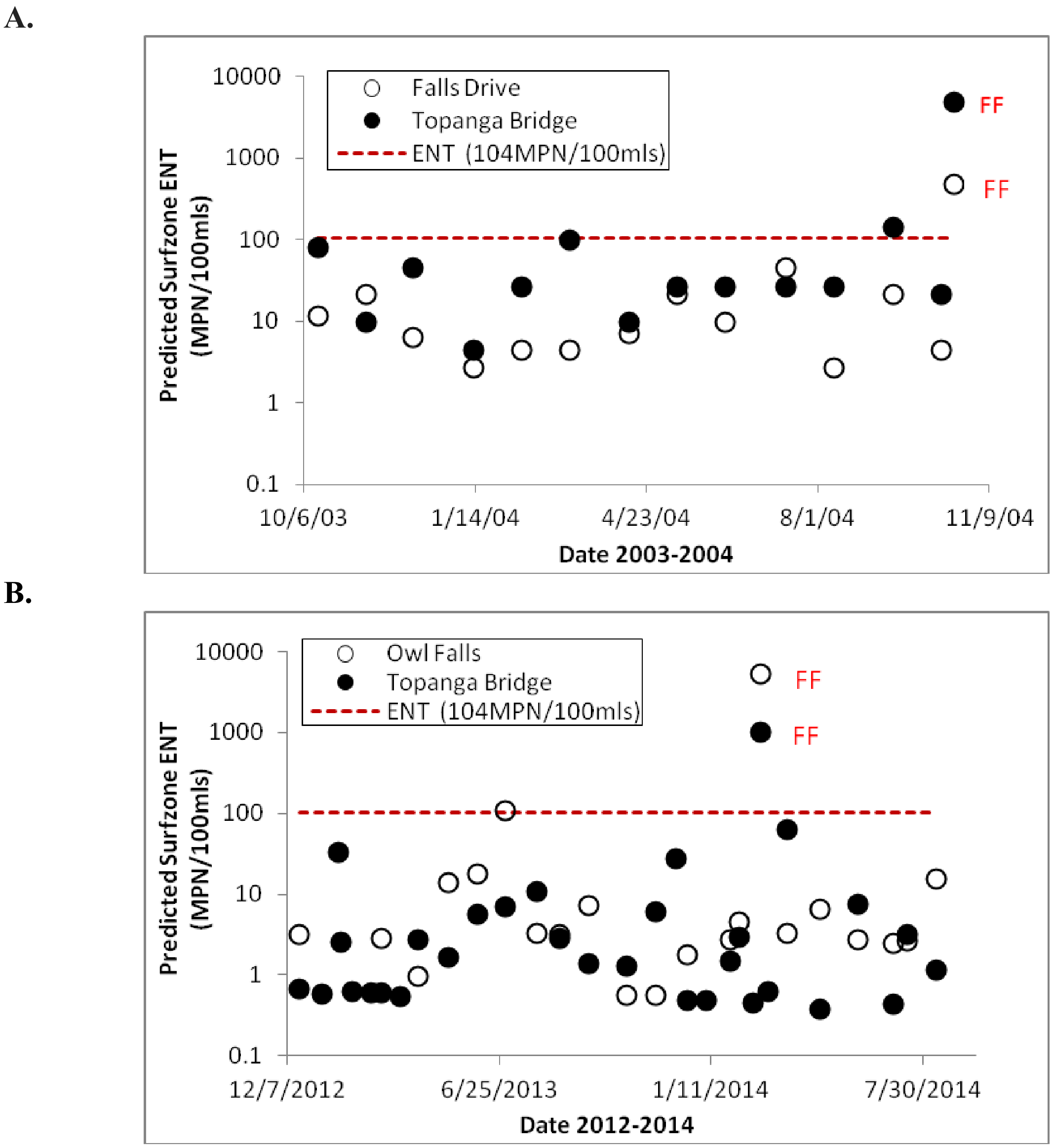


Figure 3-3. Predicted ENT concentration for surfzone FIB based on creek flow and corresponding dilution factor plotted against date. FF=first flush event. A. Predicted ENT concentration in surfzone based on FIB input from Falls Drive and Topanga Bridge during 2012-2014 study.

Spatial analysis in the lagoon of geometric means of FIB and host-associated markers

Levels of FIB in Topanga Lagoon did not vary with location or season (Figure 3-4). For the human-associated marker, a higher geomean was observed during recreational season at the lagoon outlet. However, data plots included for lagoon outlet are from year one of sampling only, though May 28, 2013. Also, there was a marked difference in the observed levels of dog-associated markers by season. Levels of the dog-associated marker in recreational season were lower than those observed in the winter for all three lagoon sites. This marker increased by ten to 100 times from the creek to the lagoon. Geomean for the gull-associated marker was 100 to 1000 times greater than levels seen in the creek. FIB levels were comparable between the three sites for wet and recreational season, indicating that FIB is fairly homogenous throughout the lagoon.

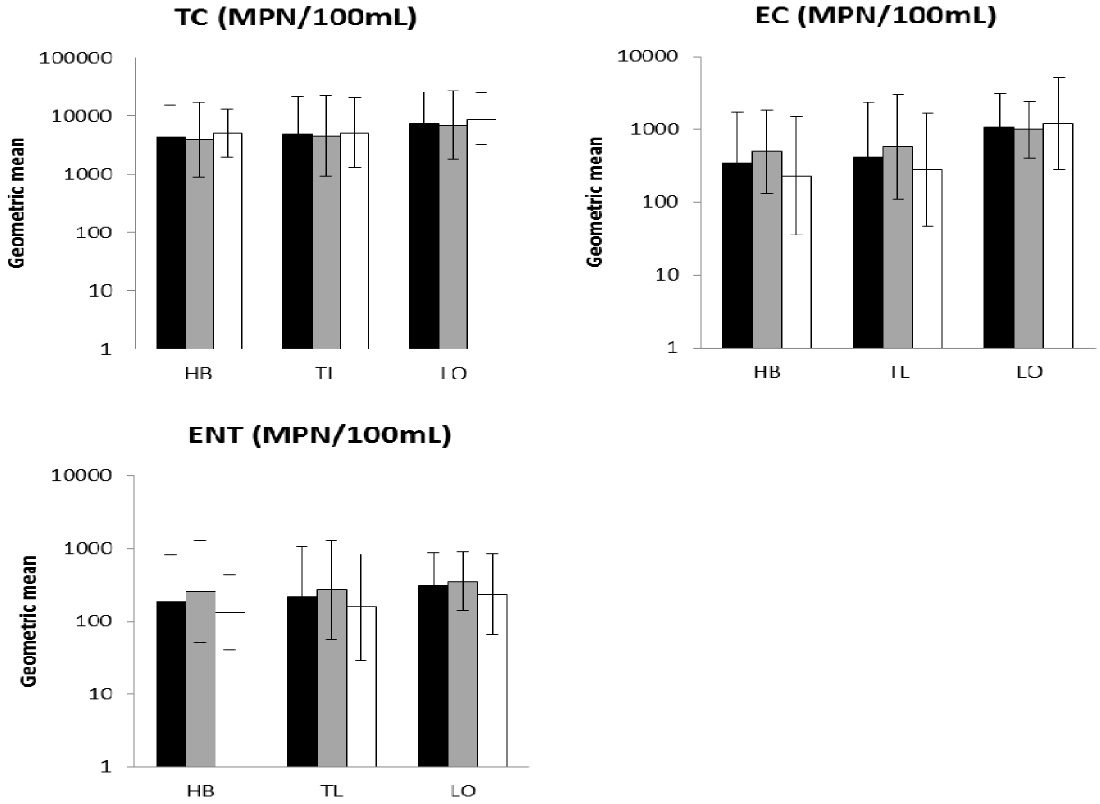


Figure 3-4. FIB values for lagoon sites (PCH Bridge over upper end of the lagoon-HB), Topanga Lagoon east wall-TL, Lagoon Outlet-LO) from 5 Oct 2011 to 11 August 2014. Note the log scale vertical axis to accommodate the large range of values and the scale range changes. The sites are ordered from north (left) to south (right). The overall geomean for each site is shown in black while grey indicates the winter season geomean and white indicates the recreational season geomean. ND indicates the limit of detection. Numbers under the x-axis indicate quantity of observations for each geomean.

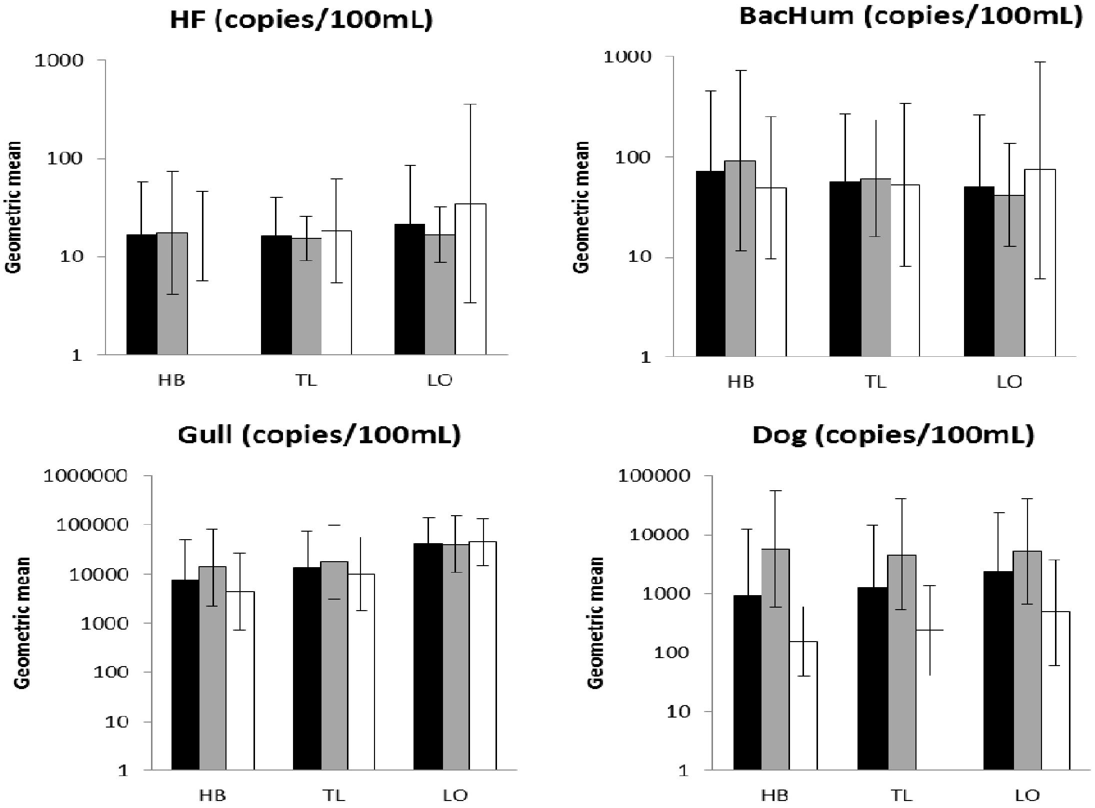


Figure 3-5. Geometric means for host-associated marker values for lagoon sites (PCH Bridge over upper end of the lagoon-HB, Topanga Lagoon east wall-TL, Lagoon Outlet-LO) from 5 Oct 2011 to 11 August 2014. Note the log scale vertical axis to accommodate the large range of values and the scale range changes. The sites are ordered from north (left) to south (right). The overall geomean for each site is shown in black while grey indicates the winter season geomean and white indicates the recreational season geomean. ND indicates the limit of detection. Numbers under the x-axis indicate quantity of observations for each geomean.

Spatial analysis in the ocean of geometric means of FIB and host-associated markers

The most striking trend for FIB levels in the ocean was the marked increase in the geomean for ENT observed from Beach Upcoast (BU), to Beach Outlet (BO), to Lifeguard (LG). The prevailing current is eastward at Topanga Beach; thus, these results suggest that the lagoon serves as a source of FIB to the ocean. Further, FIB levels at the ocean sites were higher at BO and LG (especially for ENT), indicating that upcoast sources are not likely contributing to FIB levels at BO and LG.

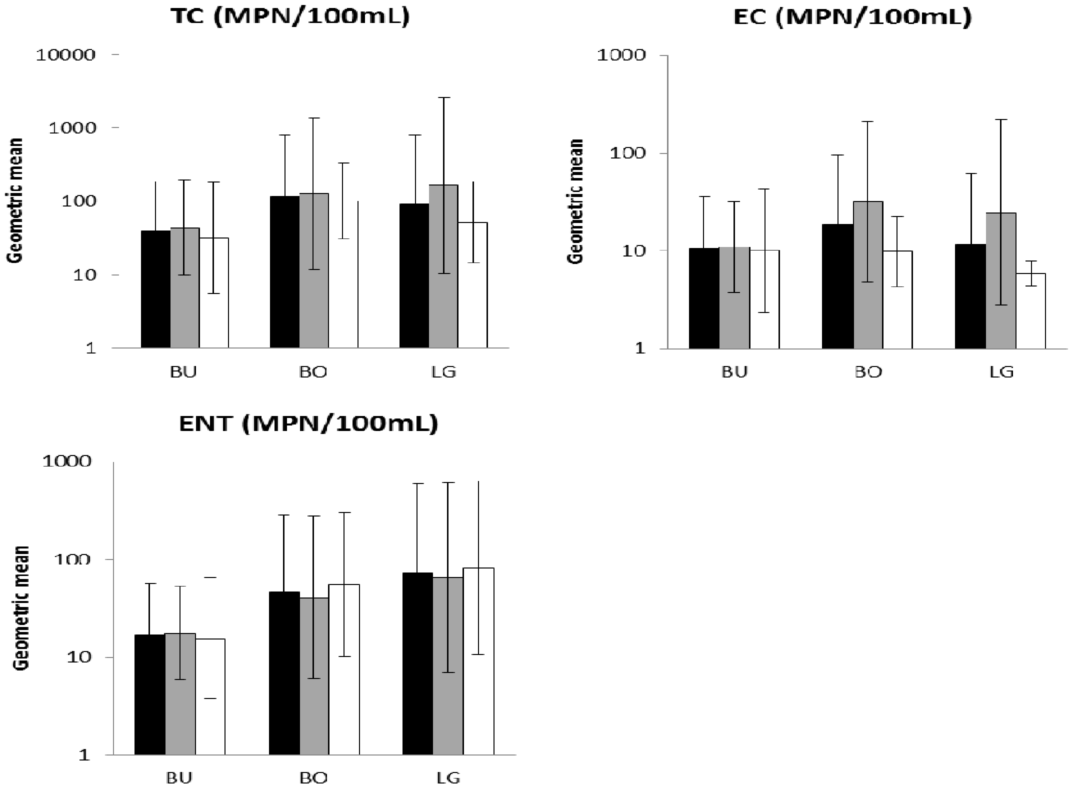


Figure 3-6. FIB values for ocean sites (Beach Upcoast-BU, Beach Outlet-BO) from 5 Oct 2011 to 11 August 2014. Note the log scale vertical axis to accommodate the large range of values and the scale range changes. The sites are ordered from west (left) to east (right). The overall geomean for each site is shown in black while grey indicates the winter season geomean and white indicates the recreational season geomean. ND indicates the limit of detection. Numbers under the x-axis indicate quantity of observations for each geomean.

In the recreational season, the human-associated marker tends to decrease in the west to east direction. This may correlate with the transient population frequenting this section of beach. Levels of dog-associated marker were also highest at BU. As seen in the lagoon, levels of dog-associated marker were higher in the winter season.

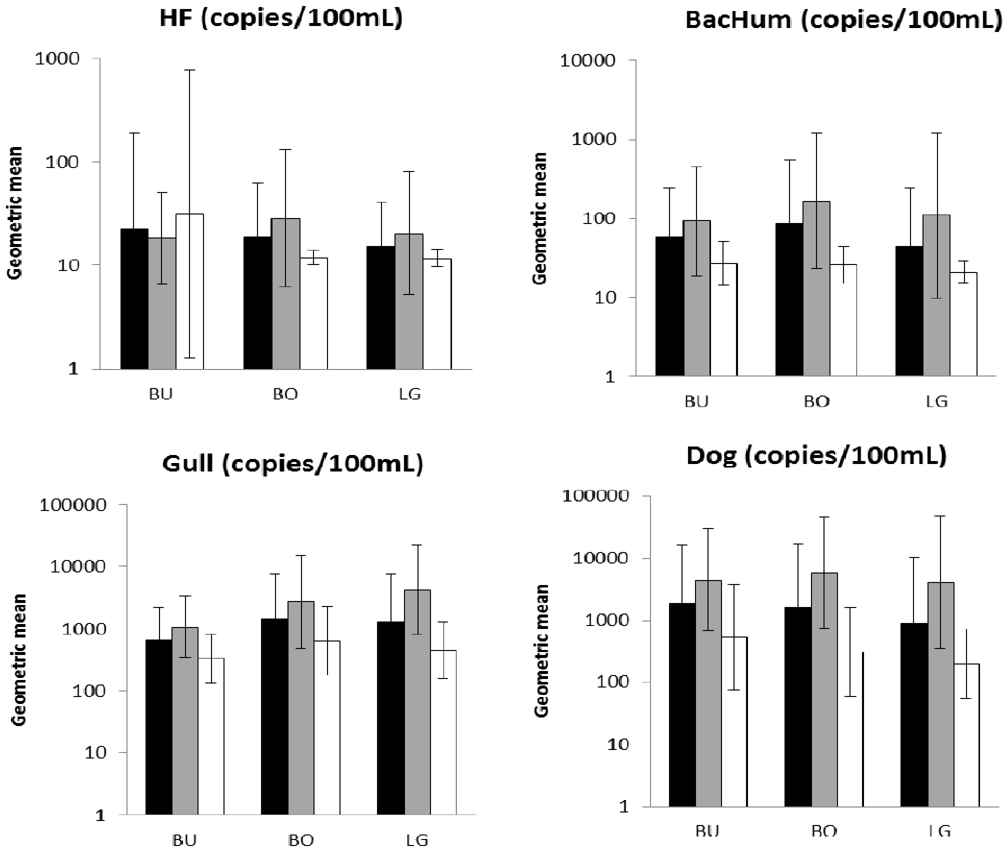


Figure 3-7. Geometric means of host-associated marker values for ocean sites (Beach Upcoast BU, Beach Outlet BO) from 5 Oct 2011 to 11 August 2014. Note the log scale vertical axis to accommodate the large range of values and the scale range changes. The sites are ordered from west (left) to east (right). The overall geomean for each site is shown in black while grey indicates the winter season geomean and white indicates the recreational season geomean. ND indicates the limit of detection. Numbers under the x-axis indicate quantity of observations for each geomean.

Analysis of Frequency of Exceedances of Bacteria Standards at Lagoon and Ocean Sites

Frequency of samples that exceeded the single sample standards of: 104 MPN/100 ml for ENT, 400 MPN/100 ml for EC, and 10,000 MPN/100 ml for TC were analyzed for BU, BO, LG, and TL. Tables 3-5 and 3-6 show the percentage of sampling dates when either TC, EC, or ENT was in exceedance.

Table 3-5. Frequency of exceedance of state bacteria standards for TC, EC, ENT at BU, BO, LG, and TL during winter and recreational seasons (April1 –Oct 31). Sampling events occurring during active rain were excluded from analysis.

	BU		**BO**		**LG**		**TL**	
	Winter	Recreation	Winter	Recreation	Winter	Recreation	Winter	Recreation
TC	0%	0%	10%	0%	8%	0%	33%	31%
EC	0%	0%	5%	0%	8%	0%	52%	44%
ENT	15%	14%	19%	33%	25%	31%	81%	69%

Table 3-6. Frequency of exceedance of state bacteria standards for TC, EC, ENT at BU, BO, LG, and TL for all sampling dates. Sampling events occurring during active rain were excluded from analysis.

	BU	BO	LG	TL
TC	0%	5%	4%	32%
EC	0%	3%	4%	49%
ENT	15%	26%	28%	76%

TC and EC exceedances were infrequent for the ocean sites, with BU in compliance of TC for all sampling dates included in analysis (all dates sampled except active rain events). However, TL exceeded 32% of the time for TC and 49% of the time for EC. For ENT, BO, BU, and LG exceeded more often, exceeding the state bacterial standard between 15 and 28% of the time. Overall, the frequency of exceedances for FIB was higher at LG and BO than at BU. TL was in exceedance for ENT and EC on more than half of sampled dates.

Analysis of ENT isolates with 16S rRNA Sequencing

Speciation of a selection of ENT isolates was completed in order to provide complementary information regarding ENT measured at the lagoon and ocean sites. Twenty isolates were isolated from mEI agar at Topanga State Beach and Topanga Lagoon, during summer 2013, and 100% of these isolates were identified as *E. faecalis*. *E.faecalis* is thought to be more fecal-associated than other species of enterococci such as *E.gallinarum* or *E.casseliflavus* (Ferguson et al., 2013).

Analysis of Frequency of Marker Detection at Lagoon and Ocean Sites

Human marker detections were infrequent at the ocean and lagoon sites, with three detections during Year one and two detections during Year two. For both years, one of these detections (and the highest level of human marker detections) corresponded with the first flush event. Presence of transients and human feces were recorded for each sampling event. Human feces were observed on seven different sampling days, while transients at Topanga Beach were recorded on 14 different sampling days. Only on February 24, 2013 did a positive human signal at BU (82 copies/100 ml) coincide with recorded observations of both transients and human feces. For the remaining 13 dates when transient activity was recorded, all samples collected at marine and lagoon sites (BO, BU, LG, HB and TL) were negative for the human marker. For human feces, the human marker was positive when the presence of human direct deposits was observed on two separate dates (Feb 24 2013 and July 2 2014). In addition, a second ocean site, LG, was also positive for the human marker on the February 24, 2013 sampling date.

Overall, the human-associated marker was detected in 13% of ocean water samples and in 14% of lagoon water samples collected during the course of the study. The human-associated HF183 marker was detected six times throughout the study at the Beach Outlet (BO), four times in the first period of the study (Oct 11 2011 – July 1 2013) and twice during the second period of the study (July 31 2013 – August 11 2014). Other marine sites were also positive for the human marker on two (LG) and four (BU) occasions (Figure 3-8).

A.

Marker	Site			Total
	BU	BO	LG	Ocean
HF183	12%	16%	8%	13%
Gull	76%	84%	80%	80%
Dog	76%	74%	58%	71%

B.

Marker	Site			Total
	HB	TL	LO	Lagoon
HF183	8%	17%	20%	14%
Gull	91%	95%	100%	94%
Dog	58%	64%	80%	64%

Figure 3-8. Frequency of detection of gull, dog, and human marker at lagoon and ocean sites for all sampling dates. A) Frequency of marker detection at ocean sites. B) Frequency of marker detection at lagoon sites.

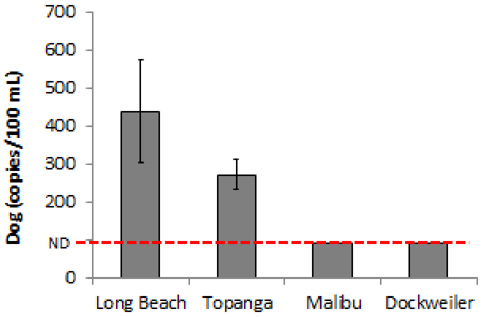
Dog and gull marker were both detected in high frequency at lagoon and ocean sites. Gull levels were detected 94% of the time in lagoon samples and 80% of the time in ocean samples. Dog marker levels were detected on average 71% of the time at ocean sites and 64% of the time at lagoon sites.

In order to better understand levels of dog marker seen in Topanga, a dog survey study was conducted to determine the impact of dog fecal waste on Topanga water quality. Sediment and water samples were collected from four beaches and analyzed for FIB and the dog marker. Levels measured at Topanga were compared to reference sites that are free of dogs and to a dog beach where dogs are permitted and regularly frequent the designated beach area. Reference beaches (Malibu and Dockweiler) were negative for the dog marker in all sediment and water samples collected. Sediment samples collected from Rosie’s Dog Beach in Long Beach, CA were also negative for the dog marker. However, all water samples from Rosie’s Dog Beach had detectable levels (219 – 823 copies/100 ml) of the dog-associated marker. Highest average ENT concentrations (91 MPN/100 ml) from all four sites sampled was measured from Rosie’s Dog beach (Figure 3-9).

Although dogs are prohibited at Topanga, levels measured from Topanga Beach were similar to those seen at the Rosie’s Dog Beach. All sediment samples were negative for the marker, except one (Site 6 – 159,303 copies/100 ml). Three of seven water samples (43%) collected on May 2, 2014 were positive for the dog marker at Topanga Beach. Water samples had dog marker concentrations ranging from 193 – 334 copies/100 ml (Figure X). FIB measured from sediment were typically low (0.5 – 7.1 MPN/g) for ocean sites. Average FIB concentrations for water samples were 51MPN/100 ml and 29 MPN/100 ml for EC and ENT, respectively.

In this single day dog survey, fecal waste did not appear to impact the sand at beaches sampled, however, there was a measureable impact on water quality.

A.



B.

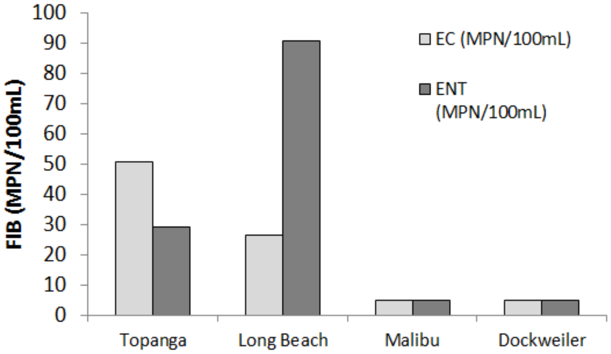


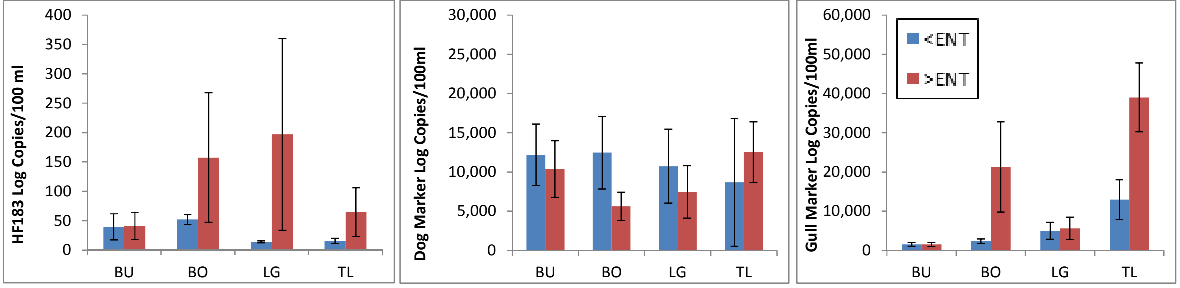
Figure 3-9. A) Average dog marker levels in water sampled during dog survey at the dog beach (Long Beach), Topanga, and the two reference beaches (Malibu and Dockweiler). B) Average FIB levels in water sampled during dog survey at the dog beach (Long Beach), Topanga, and the two reference beaches (Malibu and Dockweiler).

Relationship between FIB and DNA-marker levels at the lagoon and ocean

To determine whether exceedances in ENT or EC are indicative of a higher magnitude of host-associated fecal markers, data were combined for each of the three ocean sites and for the TL (Topanga Lagoon) site according to whether the water quality standard for enterococci of 104 MPN/100mL was exceeded or in compliance.

For the BO (Beach Outlet), LG (lifeguard Station), and TL (Topanga Lagoon) sites, there was a clear trend for increased human marker levels when ENT was in exceedance versus in compliance both when rain events were included and excluded from analysis. At BO (Beach Outlet) and TL (Topanga Lagoon) there was also a trend for increased gull marker levels when ENT was in exceedance versus in compliance.

A. Comparison of marker values with rain events included in analysis.



B. Comparison of marker values with rain events excluded from analysis.

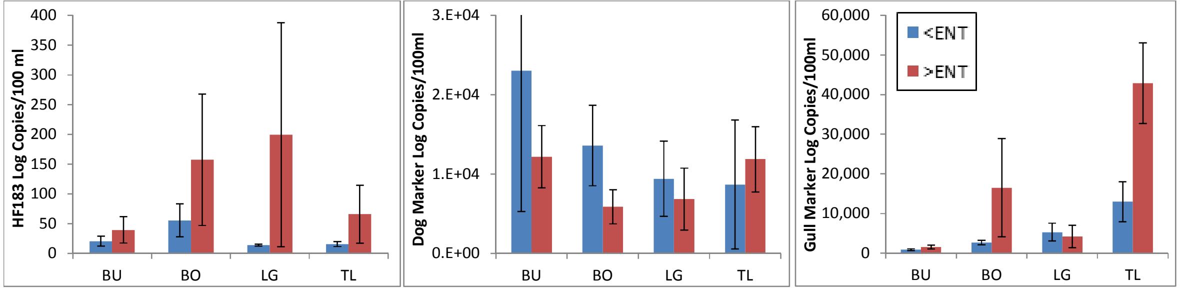


Figure 3-10. Average marker data were grouped and compared by whether ENT exceeded state water quality standards at the three ocean sites and one lagoon site: BO (Beach Outlet), BU (Beach Upcoast), LG (Lifeguard Station), and TL(Topanga Lagoon), Figure depicts average marker concentrations when ENT was in compliance (blue bars) versus in exceedance (red bars) and standard error of the mean.

Due to potential differences in environmental decay rates of these markers, it is difficult to directly compare contribution of different sources to FIB concentrations. Analysis below is solely an approximation of potential FIB concentration resulting from dog and gull sources. The geomean for the dog and gull marker for ocean and lagoon sites, on days when gull and dog marker were detected, is listed below in Table 3-7. The concentration of dog and gull marker detected was converted to gram feces per 100 ml based on 10*10^10copies per gram wet dog feces and 8.15 *10^6 copies per gram wet gull feces from prior studies (Ervin et al. 2014, Riedel et al. 2013). This was then converted to approximate CFU/100 ml *Enterococcus* based on an estimated 2.38*10^4 MPN/gram gull feces (from this study) and 8.8*10^7 CFU/gram dog feces (from Ervin et al. 2014). The relationship between grams of wet gull feces and ENT concentration was based on measurement of ENT from gull feces collected from 15 gulls at Topanga Beach on October 30, 2013.

Average input to Topanga Lagoon and ocean, based on best estimates from the literature, shows that both dog and gull are likely contributing to elevated FIB in the lagoon and surfzone. In particular, gulls appear to contribute to impaired water quality at the lagoon.

Table 3-7. Estimated enterococci concentration resulting from average dog and gull marker concentration at lagoon and ocean sites.

Marker	Site	Geomean copies/100 mls	Estimated gram feces/100 ml	Estimated ENT cfu/100 ml
DOG	BO	5705	6.E-07	50
	BU	4083	4.E-07	36
	LG	3518	4.E-07	31
	TL	4425	4.E-07	39
Gull	BO	2206	3.E-04	89
	BU	1057	1.E-04	43
	LG	2655	3.E-04	107
	TL	17542	2.E-03	710

3.4 Discussion

Within the MST portion of this study, the following hypotheses were tested and results are as follows:

1. *Lagoon discharge negatively impacts water quality at Topanga Beach.*

Based on the historical analysis, the lagoon is a source of FIB to the ocean. FIB levels are significantly increased when the lagoon is breached and connected to the ocean regardless of winter or recreational season.

2. *Concentrations of FIB and/or host-associated markers decrease as the creek flows downstream towards the lagoon.*

FIB in the surfzone do not primarily originate from an upstream creek source, except under extremely elevated FIB levels and high flow events (during first flush events). Conditions in the creek along the Narrows section, located between Owl Falls (6500 m) and Scratchy Trail (4800 m) appear conducive to a decrease in EC and ENT levels and observed levels of human- and dog-associated marker. This observed sink is also confirmed in the laboratory microcosms conducted to explore decay of FIB and markers (see Appendix J for more detail). Inactivation rates of FIB and the human marker were highest in ST and OF sediment, likely due to sediment characteristics.

Further, our predictive analysis confirms that creek FIB do not contribute significantly to surfzone FIB, except under extremely elevated FIB levels and high flow events (such as first flush events). This pattern is likely to hold during years that have increased rainfall.

3. *Spatial and temporal patterns of FIB and host-associated markers exist between sites in the lower watershed.*

Levels of FIB and all markers increase from the lower watershed creek site (SP), located 300m upstream of the lagoon, to lagoon sites. For TC, an increase of a factor of five is seen, while for EC a factor of 10-20 increase is observed. For ENT, a factor increase of 3-30 is observed. Thus, the lagoon may serve either as a location where microbial levels may be increasing due to growth or to the presence of new inputs. The host-specific markers do not multiply in the environment, thus their increase in the lagoon indicates lower watershed sources. FIB, on the other hand, may result from those fecal inputs or from environmental growth. Regardless, the lagoon appears to be a source of both FIB and host-associated markers.

4. *Lower watershed and/or lagoon sources of FIB (human and non-human inputs such as gull, dog, etc.) are correlated with exceedances at Topanga Beach.*

Dog and gull marker appear to be a significant source to the lagoon and ocean and likely contribute to exceedances seen in FIB data. Based on best estimates from the literature, when gull and dog marker concentration was converted to an estimated ENT concentration, both gull and dog marker levels were high enough to elevate surfzone and lagoon FIB. Gull levels were detected 94% of the time in lagoon samples and 80% of the time in ocean samples, indicating that gulls are an important and chronic source of fecal contamination to Topanga Lagoon and ocean sites. Further, dog marker levels in Topanga waters were similar to those measured at Rosie's Dog Beach in Long Beach, CA and were detected on average 71% of the time at ocean sites and 64% of the time at lagoon sites. This confirms that dog waste is also a significant source of fecal contamination to Topanga Lagoon and ocean.

Human marker was detected infrequently in the lagoon and ocean. There was a clear trend for increased average human marker level when ENT was in exceedance at BO, LG, and at TL. During Year 1 (July 2012 to June 2013), human-associated marker was detected in the ocean on five sampling dates, including first flush, and also on four dates in the lagoon, one of which was first flush. There was a total of seven dates with either ocean or lagoon detection. Results from Year 2 (July 2013 – June 2014) are encouraging, as human marker was detected in the ocean on just two days, one of which was first flush. For the lagoon, human hits were observed only during the first flush event of Year 2. Further sampling for the human-associated marker is recommended to determine if this trend continues and if it will continue to occur under non-drought conditions.

Summary

- The lagoon is a source of FIB to the ocean. FIB levels are significantly increased when the lagoon is breached.
- Levels of FIB and all markers increase from the most downstream creek site (SP) to the lagoon. The lagoon may serve either as a location where microbial levels may be increasing due to growth (FIB) or to the presence of new inputs (FIB and markers).
- Upstream creek sources do not appear to be a primary contributor to FIB in the surfzone, except on days when both flow and FIB levels in the upper watershed are

elevated. Days where creek input had potential to significantly impact downstream levels occurred on two sampling dates during this study, including the first flush event during year two of the study.

- Winter samples were four to eight times higher than samples for the recreational season for the dog and gull marker, indicating that these markers follow a seasonal trend and may have more of an impact to water quality during the winter.

- Dog and gull marker appear to be a significant source to the lagoon and ocean and are likely contributing to exceedances of ENT and EC state water quality standards at the ocean sites. When ENT levels were in exceedance, gull marker levels were higher than when ENT was in compliance at BO, and TL. When dog marker levels in Topanga water samples were compared to levels at two reference beaches and one dog beach, dog marker levels at Topanga were similar to levels at the dog beach. No dog marker was detected at the two reference beaches sampled (Dockweiler and Malibu).

- Human marker was detected infrequently in the lagoon and ocean. Average human marker values were higher at ocean sites when ENT was in exceedance vs. in compliance of state water quality standards. During Year 1 (July 2012 to June 2013), human-associated marker was detected in the ocean on five sampling dates, including first flush, and also on four dates in the lagoon, one of which was first flush. There was a total of seven dates with either ocean or lagoon detection. Results from Year 2 (July 2013 – June 2014) are encouraging, as human marker was detected in the ocean on just two days, one of which was first flush. For the lagoon, human hits were observed only during the first flush event of Year 2.

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4 Description of human health risk associated with human and non-human sources of fecal contamination

In Topanga, continued sampling for human-associated marker is recommended. Detailed description of human marker results are provided in the MST chapter of this report. Briefly, during Year 1 (July 2012 to June 2013), human-associated marker was detected in the ocean on five sampling dates, including first flush, and also on four dates in the lagoon, one of which was first flush. There were a total of seven dates with either ocean or lagoon detection. Results from Year 2 (July 2013 – June 2014) are encouraging, as only human hits were detected in the ocean on just two days, one of which was first flush. For the lagoon, human hits were observed only during first flush of Year 2. Further sampling is needed to determine if this trend continues and what occurs under non-drought conditions.

This study showed attenuation of upper watershed FIB sources through the creek, including the human marker. Notably, however, this study occurred under drought conditions, and extension of findings to typical conditions should be done with care. As described in detail in the MST chapter, using flow and FIB levels from both this work and a previous study conducted in 2003 - 2004 taken together, the extent to which upper watershed sources have the capacity to affect beach water quality under higher flow conditions was estimated. Conductivity measured at the beach outlet was used with flow measurements to estimate a relationship between flow and the dilution factor, which is a non-linear function of flow due to various mixing mechanisms. Using FIB data along with qualitative flow estimates from the previous study, and assuming steady flow at the lagoon, creek FIB had the capacity to cause exceedances on the beach when both flow and FIB levels are high. Specifically, ENT present at greater than approximately 1500 MPN/100 mL, which occurred twice from the 2003 – 2004 sampling effort and twice during the two-year period of this work, were projected to impact beach water quality.

Previous studies have well established that there is a correlation between the levels of FIB in recreational waters and incidence of illness when the likely source of fecal contamination is human. Landmark studies (Cabelli et al. 1982, Kay et al. 1994) provide dose-response curves between levels of FIB and observed ailments in swimmers. The risks associated with exposure to non-human sources of fecal matter in recreational water are still not well characterized, as epidemiological data on this topic are still insufficient.

Studies of the relevance of these relationships to beaches with nonhuman sources of FIB show various outcomes. There is some evidence in the literature for greatly reduced risk in water polluted by nonhuman fecal matter. Cheung et al. (1991) studied nine beaches in Hong Kong and mentioned that one beach with primarily livestock sources did not show increase risk of illness in accord with what would be predicted by the traditional models. However, differentiating between pathogenicity of sources was not a focus of the study and sources at the other beaches are not discussed.

Other studies conducted at beaches without a direct human source show increased risk of ailments in swimming populations, but not in a dose-response relationship with indicators. For example, at a marine beach without a known source of sewage, Fleisher et al. (2010) did not observe increased illness at higher levels of ENT. However, for the group of participants randomly assigned to swim, the risk of gastrointestinal, acute febrile respiratory, and skin illness increased by factors of 1.76, 4.46, and 5.91, respectively.

Similarly, in Mission Bay, CA, where FIB are primarily from nonhuman sources, a large epidemiology study showed that the incidence of illness was not associated with FIB levels (Colford et al. 2007). However, with swimming defined as any water contact at all, swimmers had significantly higher rates of diarrhea and skin rash than non-swimmers. With swimming defined as having swallowed water, the risk for diarrhea increased, and the risks for skin rash, cramps, and eye irritation were all significantly higher than for non-swimmers.

A third group of epidemiological studies do show relationships between illness and FIB levels that are comparable to those observed at beaches impacted with human waste. For example, a local epidemiological study was conducted at Doheny Beach in Orange County in 2007 and 2008 (Colford et al. 2012). Urban runoff via San Juan Creek is the largest source of FIB to this beach. In this study, 9,525 individuals were studied to determine the relative illness rates at various levels of exposure (non-swimming, body immersion, head immersion, and swallowed water.) Water quality parameters were measured traditionally; in addition, enterococci were measured by three rapid methods. Some notable findings from this study include: 1) The risk of diarrhea was significantly increased among all swimming groups compared to non-swimmers; 2) Eye infections and earaches occurred at higher rates for swimmers; and 3) FIB levels were strongly positively associated with diarrhea. The strongest association was observed for those swallowing water on days San Juan Creek was flowing into the ocean.

At beaches in Santa Monica Bay, Haile et al. (1999) studied health effects due to swimming in coastal water impacted by storm drain runoff (which had tested for presence of human associated viruses). While most epidemiological studies compare swimmers with non-swimmers, this study compared only swimmers, and took into account the distance from a storm drain and the water quality at that time and location. The three major findings: 1) The risk of many ailments was higher among subjects swimming near the storm drain; 2) There was a positive association between adverse health outcome and the levels of bacterial indicators; and 3) The relative risk was in general higher for swimming in water containing observable levels of enteric viruses.

McBride et al. (1998) studied the risk of illness at seven beaches in New Zealand. The study included two control beaches with minimally impacted water quality, two beaches impacted by animal fecal matter, and three beaches with elevated human fecal waste. The results showed risks at beaches impacted with human and non-human fecal matter to be similar, and much higher than risks at control beaches.

Thus, while the World Health Organization assumes that non-human fecal sources pose less of a risk compared to human fecal sources (WHO, 2003), data are still needed to fully understand this issue.

Interest is growing in quantitative microbial risk assessment (QMRA) as a framework for understanding risk of illness in recreational water exposure. It is based on hazard assessment (understanding which pathogens pose a risk), an exposure assessment (based on known information regarding many factors including ecology of the microorganisms), and knowledge of the dose-response relationships. A drawback to this approach is that the etiological agents in many epidemiological studies are still unknown,

Soller et al. (2010) conducted a QMRA to investigate risks following recreational water exposure to gull, chicken, pig, and cattle fecal pollution. The major findings include: 1) risks of gastrointestinal illness were found from exposure to water contaminated with both cattle and human fecal matter may be similar. While a number of human pathogens are known to be present in cattle feces, some of which are capable of causing more serious harm than a self-limiting gastrointestinal illness, the prevalence of these pathogens is unknown; and 2) risks of illness after exposure to fecal matter from gulls, chickens, and pigs seems to be much lower than those estimated after exposure to human waste in a recreational water setting. One exception could be human illness resulting from pig hepatitis E virus genogroup C (Rutjes et al. 2009).

Thus, it appears that the risk of exposure to avian sources of fecal pollution poses less of a risk than exposure to human waste. Based on a QMRA approach applied to known pathogens, Soller et al. (2014) present ENT levels that represent equivalent risk to water quality standards for waters containing mixtures of fecal sources. The authors calculate that for waters with 30% of the ENT from human sources, risk of illness is predicted to be lower; thus, higher standards could be allowed.

There is much ongoing research to fill in the data gaps required for QMRA to be an effective approach for predicting risk in recreational coastal waters. While US EPA has opened a door, site-specific water quality criteria (as would be derived from QMRA) are still not accepted in California. Increased information on etiological agents and their ecology is needed. Also, there is a dire need for QMRA predictions to be anchored with epidemiological studies.

For Topanga Beach to be a candidate for QMRA in the future, testing for host-specific markers must be continued to assess the downward trend observed in human-associated marker and to monitor reductions in dog and gull pollution as sources. These measurements must continue as the drought ends so the role of the creek can be fully assessed.

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5 Septic System Testing Results

5.1 Introduction

Topanga Beach received poor wet weather water quality ratings between 2006-2014. The beach has exceeded the water quality objectives set for Fecal Indicator Bacteria (FIB) based on the Ocean Standards (AB411) based on weekly samples collected by the City of Los Angeles Environmental Monitoring Division. This happened frequently enough for Topanga Beach to be identified by Heal the Bay as the 4th most polluted beach in the state for the 2010-2011 season and as the 10th most polluted in 2011-2012. Overall precipitation levels were very low in 2012-2013, and very low in 2013-2014 and water quality throughout the Santa Monica Bay was excellent. However, Topanga Beach was listed as "B" for summer dry (April – October 2012), "C" for winter dry (Nov 2012– Mar 2013), and "F" for wet weather year round. This pattern was repeated in 2014 however the lack of rain resulted in a wet weather grade of "C" (Heal the Bay 2014).

Los Angeles County is responsible for maintaining water quality levels at Topanga Beach that meets receiving water standards not only for FIB, but also for nutrients, trash, and several other identified beneficial uses (Table 6-21). The Regional Water Quality Control Board set TMDL's for the Santa Monica Bay overall, but not specifically for Topanga Beach, lagoon or creek. In 2012, Topanga Beach had a total of 35 exceedances of FIB levels, which was reduced to 19 exceedances in 2013 (Heal the Bay Beach Report Card 2014). One of the goals of this study is to identify potential sources of FIB so that appropriate actions can be taken to reduce the number of exceedances per year, and meet the 25% reduction goal in 2013 required by AB 411.

The septic systems located along Pacific Coast Highway (PCH) were identified as potential sources of FIB to Topanga Lagoon and beach (Hypothesis 3). Although it was not feasible to test the privately owned systems on the south side of PCH, west of Topanga Lagoon, it was possible to test the systems managed by California Department of Parks and Recreation in Topanga State Park on the north side of PCH, as well as the lifeguard station restrooms managed by Los Angeles County Department of Beaches and Harbors. These systems are physically closest to the lagoon and examining their condition and function to confirm that they are not contributing FIB was a high priority.

Aerial and ground surveys to map locations of the septic systems and their potential connectivity were completed in summer 2013. The topographic survey was conducted by Chris Nelson and Associates. Details of the system plans and locations are provided in Appendix H.

All of the septic systems located in the former Rodeo Grounds Road area were removed in 2008. The septic systems associated with the houses along Malibu Lane and in the Snake Pit area behind the Reel Inn were also removed as of 2011. In most cases, the tanks were either physically removed or backfilled. The leach fields were also backfilled and disconnected from the old tanks. Although these old systems are no longer functional, it is possible that leachate from these systems could still be trickling in through the water table to the lagoon. Modeling of the movement of septage through the water table surrounding Malibu Lagoon and Creek suggested that the time lag for movement could be years (Stone Environmental 2004). However, examination of these sites and testing with florescent dyes did not support contributions from these systems to the lagoon at this time.

Additionally, the Los Angeles County Lifeguard Station restroom facility at Topanga Beach was upgraded in 2008 with a state of the art Advantex treatment system. The renovated system incorporates state of the art chlorination, de-chlorination, and UV treatment to eliminate bacterial contamination.

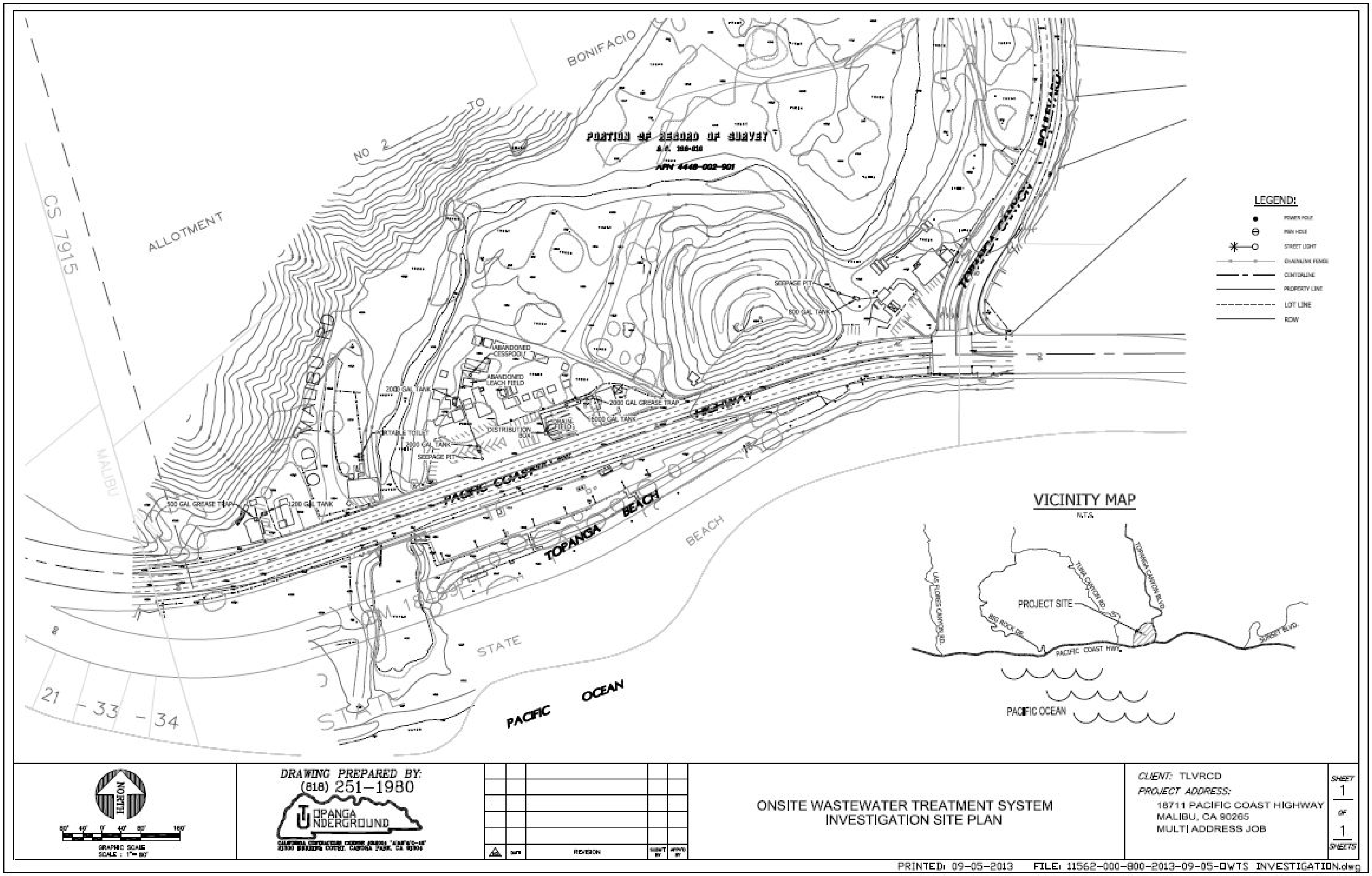

Figure 5-1 Map of Public Septic Systems adjacent to Topanga Lagoon.

5.2 Methods

Topanga State Park

Existing tanks within Topanga State Park were pumped out, then tested by backfilling to a minimum depth of 2” above the riser seam to prevent damage from hydrostatic uplift. They were then monitored for two hours. No tank was accepted if there was any leakage over the two hour period. Topanga Underground conducted testing in spring and summer 2013.

Los Angeles County Department of Beaches and Harbors Restrooms and Lifeguard Station

Water samples were pulled from the system at a sampling port where fluids pass between the UV disinfection system and the distribution box, which connects to a subsurface leach field. Samples were collected monthly from January 2013 through July 2013 by technicians from BioSolutions. Each 2 liter sample was collected and processed according to the sampling protocol, within the normal holding time by the Jay Lab at UCLA. A 500 mL sample was collected and tested for nutrients by the RCDSMM. BioSolutions also collected samples tested by Pat-Chem Inc, Moorpark, CA for: biological oxygen demand (BOD), dissolved oxygen, total suspended solids (TSS), pH, turbidity, total alkalinity, carbonate alkalinity, bicarbonate alkalinity, and hydroxide alkalinity.

Samples were held in a cooler with the Chain of Custody forms and placed within the gated area. In February 2013, we were unable to coordinate sample collection. In May and June 2013, the cooler with the empty bottles was stolen but by coordinating with the BioSolutions technician we were able to obtain samples in any case. Subsequently, we have set it up to coordinate via phone and take bottles to the technicians when they arrive on site.

5.3 Results

5.3.1 Topanga State Park

The septic systems along Pacific Coast Highway within Topanga State Park were evaluated as described above. These septic systems are being pumped weekly or more as needed, in compliance with the contracts administered by the California Department of Parks and Recreation. They are all older systems and even though no longer connected to leach fields or seepage pits, the potential for leakage is present.

SITE-3931 S. Topanga Canyon Blvd- Malibu Feed Bin- **NOT FUNCTIONAL AND POTENTIAL CONTRIBUTOR TO CREEK**

The On-site wastewater treatment system (OWTS) was located in the area to the west side of the site, on the west side of the west driveway. The system is between 40 and 50 feet from the stream bank, depending on how the top of bank is defined. The tank had a single 4" cast iron pump riser. The tank was excavated and inspected. The tank is a poured-in-place concrete septic tank, (5' x 10' x 3') with a capacity of 800+/- gallons. A radio locator, inserted into the tank outlet pipe, found a 4' x 26' seepage pit located N/W of and 15' from the tank.

The system is not functional at this time. The seepage pit was 100% full and backed up into the tank during the inspection. We notified the Feed Bin manager that the tank and the pit needed to be pumped. Two 8" pumping risers were installed on the tank and the pit has an existing 4" pumping riser. There was no evidence of sewage or effluent surfacing over the tank or the pit. The seepage pit servicing this system could be a contributor to bacteria in the creek, if there is a below-grade path, which permits the effluent seeping out of the pit to travel to the creek. This connection was not documented at this time and would require use of dyes to test connectivity. As pointed out, the distance is probably less than 50 feet from the pit to the creek.

Recommendation: The tank outlet line should be capped so that the seepage pit is no longer in use. The septic tank will then have to be pumped as required. If the total use causes the tank to fill up weekly, a 6,000 gallon holding tank can be rented, and a float operated pump placed in the septic tank, discharging to the tank. A larger truck can then be used to dispose of the sewage. Pumping cost will have to be determined and the cost of tank rental and installing the pump looked at to determine the least expensive option.

SITE-18661 Pacific Coast Highway-Reel Inn – **Not expected to be a contributor**

The system is located at the parking lot west of the restaurant. The system consists of a 2000 gallon grease trap, a 6000 gallon septic tank, a D-Box and a 3900 sq. ft. leach field. The leach field is at least 200 feet from the creek both to the west and the north. It does not appear that this system is a contributing factor to the problems in Topanga Lagoon and beach.

Both the tanks are being pumped on a regular basis. We believe that the timing of the pumping and the rate at which the tanks fill up do not coincide and that occasionally the system discharges effluent to the leach field.

Recommendation: Develop and implement a more effective pumping plan to avoid discharges.

SITE-19711 Pacific Coast Highway-Ranger Station – **May be a contributor**

This system has several components. There is a 4" clean out on the sewer line behind the partially occupied Ranger cabin. There is an abandoned 14 foot cesspool located between a palm tree & the nearby small tree adjacent to the ranger house. This is apparently not connected to anything & was dry. By water testing and some pipe cleaning, we determined that the Ranger Cabin was draining to the tank west of the main driveway (#1), between the first row of cabins and the ranger cabin. This tank (#1) was checked and it was basically empty. We believe that the bottom of the tank is cracked and effluent is seeping out and that is the reason the tank is empty. This tank is closer to the top of bank north of the bridge that any other tank on all the sites. Tank (#1) was pumped empty and 6" of concrete placed over the existing floor. This should prevent any future leakage.

By water testing the Tank #1 outlet we believe that if full, it would overflow into the larger tank (#2) located in the front parking lot adjacent to PCH, which served the former market (removed in 2002). Tank #2 had some water in it, but there is nothing flowing into it at this time. Tank #2 is connected to seepage pits in the front PCH parking lot. This system is close to the creek and could be a contributor to bacteria levels.

Recommendation: Repair the leak in Tank #1 (completed in September 2013). Plug both the inlet and outlet to test the tank following the repair. Repair the cracked manhole covers located in the PCH parking lot. Conduct dye tests to determine if any leaching is making it to the creek/lagoon.

SITE-19741 Pacific Coast Highway-Rosenthal Wine- **Not contributing from an OWTS.**

This site was inspected and there does not appear to be any OWTS in use on the site. The bathroom in the building had no fixtures and there are several Portable Toilets outside the building. This site is actually the closest building to the creek, however as there is no system in use, this location does not contribute to the bacteria levels via an OWTS. However, there is regular surface run-off from the site associated with irrigating the lawn.

Recommendation: Reduce irrigation and prevent run-off directly from the surface to the lagoon.

SITE-19753 Pacific Coast Highway-Something Fishy – **Not contributing**

The OWTS for this site is still in place, however the building was removed some years ago and the system is not in use. We believe that when this system was in use it was located behind the building and was over 100 feet from the creek.

This system is not contributing to the problem.

SITE-18757 Pacific Coast Highway-Wiley's Bait Shop – **Not contributing**

The building has no bathroom facilities. There is a single sink discharging into a 3' X 3' gravel packed pit. The shop uses the toilet facilities at Cholada's. This site is over 200 feet from the creek.

This system is not contributing to the problem.

SITE-19763 Pacific Coast Highway-Cholada Restaurant – **Not contributing**

The OWTS consists of an 800± gallon Grease Trap and a 1500± gallon septic tank. The grease trap is located under the kitchen floor and the septic tank is in the parking lot east of the building. This system is over 250 feet from the creek.

The system is not connected to the original leach field. Both tanks are being used as holding tanks and they are being pumped as needed.

This system is not contributing to the problem.

5.3.2 Los Angeles County Department of Beaches and Harbors Restrooms and Lifeguard Station

FIB and Marker results are summarized in Table 5-1 through Table 5-7. It was interesting to note that even after advanced septic processing that kept FIB levels quite low, DNA from dead cells was detected by both human marker tests and are present in almost every sample (Table 5.4-5-5). The detection of Dog DNA in April 2013 (Table 5-6) is consistent with additional information from 2014 (see Figure 3-7). Based on the FIB results summarized in Tables 5-1 to 5-3, it does not appear that the lifeguard septic system is contributing FIB to either the lagoon or ocean.

Table 5-1 Total coliform levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast. FF=First Flush.
(Exceedance >10,000 MPN/100mL)

Date	Lifeguard MPN/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon MPN/100mL	Beach Outlet MPN/100mL	Beach Upcoast MPN/100mL
11/17/12 FF	ND*	Not collected	54750	638	Not collected
11/29/12	Not collected	Not collected	29090	341	341
12/19/12	ND	Not collected	13760	98	75
1/9/13	<10	Not collected	1664	41	20
2/6/13	ND	Not collected	4611	327	605
3/6/13	2400	Not collected	4352	41	10
4/10/13	794	Not collected	4786	75	<10
5/8/13	185	97	2254	63	52
6/5/13	2224	199	2282	2489	10
7/1/13	414	86	2098	141	20
7/31/13	Not collected	52	7270	201	960

*ND= Not detectable

Table 5-2 E. coli levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast. FF=First Flush.
(Exceedance >235 MPN/100mL)

Date	Lifeguard MPN/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon MPN/100mL	Beach Outlet MPN/100mL	Beach Upcoast MPN/100mL
11/17/12 FF	ND*	Not collected	1723	97	Not collected
11/29/12	Not collected	Not collected	2098	160	110
12/19/12	ND	Not collected	1376	10	20
1/9/13	<10	Not collected	327	31	<10
2/6/13	ND	Not collected	712	41	52
3/6/13	<10	Not collected	933	20	<10
4/10/13	<10	Not collected	1835	<10	<10
5/8/13	<10	<10	41	<10	<10
6/5/13	<10	<10	52	<10	<10
7/1/13	41	<10	41	10	<10
7/31/13	Not collected	<10	171	<10	187

*ND= Not detectable

Table 5-3 Enterococcus levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast.
(Exceedance >104 MPN/100mL saltwater and >61 MPN/100mL for freshwater)

Date	Lifeguard MPN/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon MPN/100mL	Beach Outlet MPN/100mL	Beach Upcoast MPN/100mL
11/17/12 FF	ND*	Not collected	2014	121	Not collected
11/29/12	Not collected	Not collected	495	10	31
12/19/12	ND	Not collected	171	63	20
1/9/13	<10	Not collected	86	31	20
2/6/13	ND	Not collected	142	10	31
3/6/13	50	Not collected	455	52	148
4/10/13	30	Not collected	350	20	20
5/8/13	10	3873	10	279	<10
6/5/13	327	4106	30	480	10
7/1/13	399	52	52	86	<10
7/31/13	Not collected	97	5794	75	231

*ND= Not detectable

Table 5-4 Human Marker (HF183 copy/100mL) levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast.

Date	Lifeguard Copy/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon Copy/100mL	Beach Outlet Copy/100mL	Beach Upcoast Copy/100mL
11/17/12 FF	Not collected	Not collected	Not collected	375.0	Not collected
11/29/12	Not collected	Not collected	ND*	286.26	672.98
12/19/12	Not collected	Not collected	ND	ND	ND
1/9/13	2616.37	Not collected	ND	69.50	ND
2/6/13	Not collected	Not collected	ND	2.02	ND
3/6/13	1600.4	Not collected	ND	ND	ND
4/10/13	36894.7	Not collected	41.5	ND	ND
5/8/13	ND	ND	ND	ND	1.60
6/5/13	1335.41	ND	ND	ND	ND
7/1/13	357984.86	ND	ND	ND	ND
7/31/13	Not collected	ND	ND	ND	ND

*ND= Not detectable

Table 5-5 BacHum Marker levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast.

Date	Lifeguard Copy/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon Copy/100mL	Beach Outlet Copy/100mL	Beach Upcoast Copy/100mL
11/17/12 FF	Not collected	Not collected	52.0	ND	Not collected
11/29/12	Not collected	Not collected	6.05	2538.48	2777.04
12/19/12	Not collected	Not collected	ND*	ND	ND
1/9/13	23238.23	Not collected	136.3	ND	203.0
2/6/13	Not collected	Not collected	ND	ND	139.8
3/6/13	29700.91	Not collected	ND	ND	ND
4/10/13	246173.94	Not collected	ND	ND	ND
5/8/13	387.9	ND	ND	ND	ND
6/5/13	8511.73	ND	ND	ND	ND
7/1/13	2874282.3	ND	ND	ND	ND
7/31/13	Not collected	Not collected	Not collected	Not collected	Not collected

*ND= Not detectable

Table 5-6 Dog Marker levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast.

Date	Lifeguard Copy/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon Copy/100mL	Beach Outlet Copy/100mL	Beach Upcoast Copy/100mL
11/17/12 FF	Not collected	Not collected	2994.2	4035.6	Not collected
11/29/12	Not collected	Not collected	1426.68	53923.28	17000.46
12/19/12	Not collected	Not collected	10269.38	4975.98	1624.98
1/9/13	ND*	Not collected	73633.80	24444.72	3297.54
2/6/13	Not collected	Not collected	37148.38	42461.54	28518.41
3/6/13	ND	Not collected	2158.12	15952.18	15615.57
4/10/13	1743.10	Not collected	8405.10	1728.21	ND
5/8/13	ND	ND	ND	281.8	745.56
6/5/13	ND	ND	ND	96.8	152.4
7/1/13	ND	263.4	ND	ND	3434.6
7/31/13	Not collected	ND	ND	ND	ND

*ND= Not detectable

Table 5-7 Gull Marker levels at Lifeguard treatment system, Topanga Lagoon, Beach Outlet, Beach Upcoast.

Date	Lifeguard Copy/100mL	Ocean in front of Lifeguard Copy/100mL	Topanga Lagoon Copy/100mL	Beach Outlet Copy/100mL	Beach Upcoast Copy/100mL
11/17/12 FF	Not collected	Not collected	22068.5	4469.8	Not collected
11/29/12	Not collected	Not collected	5501.23	2450.21	519.44
12/19/12	Not collected	Not collected	5439.32	2409.06	747.99
1/9/13	ND*	Not collected	51901.53	566.8	560.7
2/6/13	Not collected	Not collected	81223.73	9152.85	3087.84
3/6/13	ND	Not collected	108604.31	1292.57	777.99
4/10/13	ND	Not collected	122849.0	2524.8	746.1
5/8/13	ND	ND	2179.4	ND	ND
6/5/13	ND	32.32	3428.15	652.27	705.97
7/1/13	ND	893.47	12599.36	698.80	22.77
7/31/13	Not collected	ND	5911.6	4252.8	501.6

*ND= Not detectable

In May 2013, surface runoff was observed from the concrete apron of the showers at the Lifeguard station to the ocean. Between May and July 2013, samples were collected in the swash zone of the ocean near the location drainage was observed. Based on high enterococcus readings documented in May 2013 during a rain event, the Los Angeles County Department of Beaches and Harbors examined the plumbing to make sure that all shower water is being captured by the septic system as per design, and conducted the maintenance required to keep the connections functioning (Figure 5-2). Subsequent testing suggests that this may be a wet weather problem only. The high enterococcus numbers could also be related to the detection of both dog and gull markers. It was interesting that no human markers were detected.

Figure 5-2 Photograph of the collection system at the Topanga Beach Restroom showers

Nutrient levels in the lifeguard septage samples tested by the RCDSMM were consistently extremely high and most required a 1/100 dilution in order to even test given the limitations of the colorimeter. Nitrate-N, ammonia–N, orthophosphates were in exceedance (Tables 5-8 to 5-12) in all samples. On 5 June 2013, the samples were not diluted and thus were completely over-range.

Table 5-8 Nitrate-N (ppm) comparison between Lifeguard septage and Topanga Lagoon
Water Quality Objective < 1 ppm

Date	Lifeguard (ppm) 1/100 dilution	Topanga Lagoon (ppm)
1/9/13	12.00	0.00
2/6/13	No data	0.00
3/6/13	45.00	0.00
4/10/13	62.00	0.00
5/8/13	48.00	0.11
6/5/13	No data	0.06
7/1/13	21.00	0.00
7/31/13	74.00	0.00

Table 5-9 Nitrite-N comparison between Lifeguard septage and Topanga Lagoon
(Water Quality Objective < 1 ppm)

Date	Lifeguard (ppm)	Topanga Lagoon (ppm)
1/9/13	0.13	0.0
2/6/13	0.09	0.04
3/6/13	0.09	0.0
4/10/13	28	0.05
5/8/13	0.45	0.0
6/5/13	No data	0.02
7/1/13	0.0	0.01
7/31/13	0.61	0.0

Table 5-10 Ammonia–N comparison between Lifeguard septage and Topanga Lagoon
(Water Quality objective for freshwater is < 0.4 ppm, ocean < 2.4 ppm)

Date	Lifeguard (ppm) 1/100 dilution	Topanga Lagoon (ppm)
1/9/13	12	0.13
2/6/13	16	0.0
3/6/13	30	0.0
4/10/13	33.6	0.1
5/8/13	11	0.13
6/5/13	No data	0.15
7/1/13	71	0.0
7/31/13	36	0.0

Table 5-11 Orthophosphate comparison between Lifeguard septage and Topanga Lagoon
(Water Quality Objective < 0.10 ppm)

Date	Lifeguard (ppm) 1/100 dilution	Topanga Lagoon (ppm)
1/9/13	9.9	0.05
2/6/13	33	0.03
3/6/13	25	0.04
4/10/13	33	0.01
5/8/13	27	0.08
6/5/13	No data	0.06
7/1/13	24	0.03
7/31/13	68	0.06

Table 5-12 Turbidity comparison between Lifeguard septage and Topanga Lagoon
(Water Quality Objective < 5 NTU)

Date	Lifeguard (ppm)	Topanga Lagoon (ppm)
1/9/13	2.16	No data
2/6/13	0.97	0.13
3/6/13	45	3.86
4/10/13	8.97	8.42
5/8/13	3.21	2.26
6/5/13	No data	3.11
7/1/13	2.26	0.79
7/31/13	1.6	0.89

The following table shows the results of using only the available alkalinity.

Table 5-13 Pat-Chem Laboratory Test Results

Pat-Chem Lab- Biosolutions								
Parameter	1/9/13	2/6/13	3/6/13	4/10/13	5/8/13	6/5/13	7/1/13	7/31/13
Biological Oxygen Demand (mg/l)	28	18	40	29	29	26	23	16
Dissolved Oxygen (mg/l)	7.8	8.3	6.8	7.6	7	4.2	6.5	7.2
pH	3.3	3	4.1	7.6	4.4	5.7	6.8	4.2
Total Alkalinity (mg/l)	1	1	1	54	1	12	216	1
Carbonate Alkalinity (mg/l)	1	1	1	1	1	1	1	1
Bicarbonate Alkalinity (mg/l)	1	1	1	54	1	12	216	1
Hydroxide Alkalinity (mg/l)	1	1	1	1	1	1	1	1
Total Suspended Solids (mg/l)	13	7	180	28	12	12	6	6
Turbidity (NTU)	4.3	1.5	103	10	5.4	4	2.7	3.8

5.4 Discussion

The function of septic systems located adjacent to the beaches, wetlands, and lagoons, are a concern throughout the country. The combination of high water tables, limited filtration distance through sandy soils, and close proximity to inundation by high tides can cause unintended connectivity between septic leach fields and the ocean (Izbecki 2011). The proximity of septic systems located at Topanga Beach, and adjacent to the beach and lagoon were identified as possible contributors to the exceedances recorded at Topanga Beach.

There is always a remote possibility that there is some historical sewage effluent that is leaking into the creek from old systems. Note that presently and in the past all the sewage effluent was discharged to either seepage pits or leach fields and this eventually ended up in the water table below the area. If the geology at the below-grade elevation of the upper part of the water table was such that there is or was geologic features that eventually permitted the water table to migrate to the creek, there could be contamination.

A study in the Malibu Civic Center concluded that the septic systems, in the shopping centers along Cross Creek Road ended up in the Malibu Lagoon rather quickly and that there were some systems around the perimeter, of the Civic Center that may take 75 years to migrate to the Lagoon (Izbicki 2011, Stone Environmental 2004). The siting of the leach field for the Lifeguard treatment system suggests that effluent would have to travel through the fill material into groundwater at least 393 feet before it would discharge into Topanga Lagoon. It would have to travel at least 285 feet before discharging into the ocean.

With the 2008 upgrade of the Topanga Beach Lifeguard Station Restrooms, waterless urinals were installed to reduce water consumption along with the installation of an Advanced Treatment System to meet the California Ocean Plan. The goal for the treatment plant is to nitrify the existing TKN (ammonia and organic nitrogen) to the California Ocean Plan standard of <2.4 mg/L ammonia (SWRCB 2009). With the addition of the waterless urinals and water reduction faucets and showerheads, water dilution for the incoming ammonia was reduced and TKN before treatment increased.

The nitrification process consists of a recirculation of water over a textile media utilizing ambient air for oxygen. An alkalinity of 7.14 ppm is required to convert 1 ppm ammonia to nitrate. The available alkalinity provided in the incoming potable water from LA County Water District 29's 2012 report was an average of 79 ppm. Any additional demand for alkalinity would start coming from the pH in the wastewater until this was consumed. As the pH falls, the treatment process loses efficiency and recirculation has to be reduced to prevent die-off of beneficial bacteria. The necessary alkalinity needed to convert the ammonia is as follows:

> 132 ppm TKN x 7.14 ppm alkalinity = 942.48 ppm alkalinity.
>
> 942.48 ppm needed alkalinity – 79 ppm available alkalinity = 863.48 ppm supplemental alkalinity needed to convert TKN and maintain neutral pH.

The function of the Lifeguard treatment system could be improved with the addition of a chemical feed alkalinity system, similar to that installed at all the new Zuma, Point Dume, and Surfrider Beach systems. By installing an automatic injection system of soda ash to supplement the alkalinity needed for proper nitrification and TKN (ammonia) conversion, the system could knock down the ammonia content to below 2.4mg/L and bring the pH up to an acceptable level between 6.5 and 9. The monitoring results from the Surfrider Beach Treatment system illustrate the reductions possible (Table 5-14). This would also help with other treatment factors, as the beneficial bacteria in this system are being significantly affected and possibly killed by the acidic pH.

Table 5-14 Los Angeles County Sampling Results for Surfrider Beach Treatment System

LA County –Malibu Monitoring Project					
Parameter	2/24/12	4/20/12	10/26/12	2/8/2013	5/10/13
Biological Oxygen Demand (mg/l)	5.81	15.4	4.85	5.95	ND*
ammonia-N(mg/l)	0.160	0.180	0.411	0.570	1.67
pH	8.34	6.88	6.08	8.09	7.88
Total coliform (MPN/100mL)	ND	ND	130	ND	2400
Fecal coliform (MPN/100mL)	ND	ND	ND	ND	20
Enterococcus (MPN/100mL)	ND	ND	ND	ND	ND
Turbidity (NTU)	2.95	1.05	2.13	11.7	0.560

*ND= Non Detect

Nitrates and nitrites are expected to be high as they are part of the chemical breakdown of ammonia in the nitrification process. If necessary, Total Nitrogen could also be lowered by adding additional equipment to de-nitrify the effluent. Currently that is not required at beach areas under the California Ocean Plan (SWRCB 2009). This upgrade has been discussed with Los Angeles County Public Works and a quote was provided to then a year or so ago. They seemed open to the idea of retrofitting these older beach treatment systems. Funding for such upgrades may be available through the State Water Resources Control Board, as recommended in SWRCB resolution 2012-0032.

5.5 References Cited

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6 Nutrient and In-situ Testing Results

6.1 Introduction

Although bacteria levels are a main focus of this investigation, the aquatic health of Topanga Lagoon and creek is influenced by numerous other factors. In 2003-2004, we identified total suspended solids and nutrients as potential problems in the upper watershed above the town of Topanga. Eutrophication describes the excessive growth of algae and plant matter due to the increased input of factors needed to photosynthesize, such as nutrients. Eutrophication occurs naturally in freshwater ecosystems over time with sedimentation; however, the process has been accelerated in many places due to nearby human activity. Input of nutrients can be from point (e.g., wastewater treatment plants, culverts) or non-point (e.g., fertilizer runoff) sources.

Aquatic species typically tolerate levels of nutrient loading that are lower than drinking water standards used to evaluate water quality. For instance, the drinking water standard used by the Regional Water Quality Control Board to regulate discharge from sewage treatment facilities for nitrogen–N is 10 mg/L. The EPA limit for freshwater aquatic systems for nitrogen-N is 1 mg/L (EPA 2012). In Malibu Creek that is also the target proposed.

Additionally, excessive nutrients typically lead to algae blooms, which can affect in-situ water quality parameters, such as pH and dissolved oxygen. For instance, when algae and plants are photosynthesizing during the day, dissolved oxygen levels will be high, however, when they respire at night, or die, oxygen is depleted. Aquatic organisms typically require a consistent level of 5 mg/L or above of dissolved oxygen to survive, and when levels drop below this, it can be detrimental to the aquatic wildlife (LARWQCB 1994 with 2011 updates).

The goal of this part of the study was to determine if nutrient loading was an issue in Topanga Creek and if so, if nutrient levels, along with bacteria levels, decreased from upstream sites to downstream sites as water moves through the natural section of the Narrows and the lower watershed below town.

6.2 Methods

Samples were collected just below town at Owl Falls (OF; 6500 m), further downstream at Scratchy Trail (ST; 4800 m), Topanga Bridge (TB; 3600 m), Brookside Drive (BR; 1700 m), Snake Pit (SP; 300 m), and in Topanga Lagoon (TL; 0 m) from 2012 to 2014. Samples collected from OF and ST were done so with funding from SIPP (Source

Identification Project). All other samples were collected thanks to funding from LA County Supervisor Zev Yaroslovsky's office. Standard Citizen Water Quality Monitoring parameters were incorporated into the sampling effort, which provided an outreach opportunity for RCDSMM Stream Team volunteers, local students, and during the 2013-2014 year, members of the Watershed Stewards Project.

Water samples were collected in the field in 500 mL bottles. Bottles were rinsed three times and filled and capped underwater. Samples were collected monthly during the dry season (April – October) and bi-weekly during the wet season (November – March), and at the first flush rain event (> 0.75") at the same time and locations as FIB samples. Nutrient testing (nitrate-N, nitrite-N, orthophosphates, ammonia-N) of grab samples was done within six hours of collection using a LaMotte SMART3 Colorimeter. Turbidity was tested using a LaMotte Turbidimeter 2020we.

In-situ parameters included water temperature, pH, salinity, conductivity, and dissolved oxygen. Water temperature (ºC) and dissolved oxygen (mg/L and % saturated) were tested using a handheld YSI 55 DO meter. Conductivity (µS/cm) and pH were tested using handheld Oakton probes (waterproof ECTestr11 and waterproof pHTestr 30, respectively). Salinity (ppm) was tested using a handheld refractometer (ATC 300011 SPER SCIENTIFIC salt refractometer). Air temperature was measured using a mercury thermometer.

Algae cover was measured and recorded in two ways: 1) visual estimate of percent cover, and 2) random point contact (RPC) where a random point is generated on a transect stretching across the creek where flow is taken and the substrate below that point is recorded. Substrate was recorded as: terrestrial plant, aquatic plant, algae unknown, *Cladophora, Enteromorpha,* diatoms, bare bedrock, bare boulder, bare cobble, bare gravel, or sand. A complete description of the methodology is found in Appendix G.

6.3 Results

6.3.1 Physical Conditions

6.3.1.1 Lagoon-Ocean Connection

The connection between Topanga Lagoon and the ocean was monitored at every rain event and sampling event by the project team as well as daily by the Los Angeles County Lifeguards until June 2013. When possible, breaches were noted as manual or natural as well. We also relied upon daily monitoring using the web camera located on top of the lifeguard station. Although images were blurry, they did allow us to detect lagoon connections.

Substantial rainfall events were minimal and total rainfall was below normal for 2012-2013 and 2013-2014 water years (WY; Table 6-1). Similarly, breach events that connected the lagoon to the ocean were quite limited in both years (Table 6-2). Connection lasted for less than ten days in 2012-2013, and fewer than seven days in 2013-2014. The breach in April 2013 was manually done by a local shovel brigade and recorded by the lifeguards.

Table 6-1 Rainfall events and water year (WY) totals in Topanga, CA, 2012-2014.

Wet Spell Dates	**Rainfall Amount (in.)**
20 Oct 12	0.02
23 Oct 12	0.03
8 Nov 12	0.08
16-18 Nov 12*	0.87
28 Nov to 3 Dec 12	2.55
12 Dec 12	0.42
14-18 Dec 12	0.67
22-26 Dec 12	1.59
23-27 Jan 13*	1.65
8 Feb 13	0.06
19 Feb 13	0.23
6-8 Mar 13	1.06
30-31 Mar 13	0.18
24 Apr 13	0.01
6 May 13	0.54
2012-2013 WY TOTAL	9.96
09 Oct 13	0.06
20-22 Nov 13	0.80
29 Nov 13	0.03
07 Dec 13	0.18
02 Feb 14	0.02
06 Feb 14	0.24
09 Feb 14	0.01
26-28 Feb 14*	5.34
01-02 Mar 14	0.20
2013-2014 WY TOTAL	6.88

*First flush events (>0.75”) 17 Nov 2012, 24 Jan 2013, 27 Feb 2014

Between Dec 2012 and Aug 2014, there were several “king” tide events, where unusually high tides (generally over 6.5’) caused overwash from the ocean to the lagoon, although they did not always results in a full breach (Table 6-2).

Table 6-2 Topanga Lagoon high tides, overwash, and breach events, November 2012 – August 2014.

Date	High Tide Time	Tide Height (ft)	Breach Events and Rain event Date, inches	Sand Berm Condition
16-20 Nov 12				Overwash at high tide/rain pulse
11 Dec 12	18:46	6.9		Closed
12 Dec 12*	19:30	7.2		Closed
13 Dec 12	20:16	7.3		KING TIDE Overwash at high tide
14 Dec 12	21:02	7.1		Overwash at high tide
09 Jan 13	06:35	6.7		Cosed
11 Jan 13	09:41	6.4		Overwash at high tide
25 Jan 13	07:42	5.8	Breached, 23-27 Jan 13, 1.65”	Overwash at high tide
26 Jan 13	08:14	5.9		Connected
27 Jan 13	08:46	5.8		Overwash at high tide
28 Jan 13	09:19	5.6		Overwash at high tide
30 Jan - 2 Feb 13			Breached, rain same as above	Connected
6 Feb 13	05:34	5.9		Overwash at high tide
9 Feb 13	08:04	6.5		Overwash at high tide
26-28 Feb 13			Breached, 26 Feb-01 Mar 13, 5.51”	Connected/OW at HT
6 Mar 13	04:17	5.1	Breached, rain same as above	Closed-perched**
8-14 Mar 13			Breached, rain same as above	Connected/OW at HT
16 Mar 13	12:13	4.9	Breached, rain same as above	Overwash at high tide
20 Mar 13	04:31	4.0	Breached, rain same as above	Connected
24 Mar 13	08:42	5.1	Breached, rain same as above	Overwash at high tide
10 Apr 13	10:14	4.5		Closed-Perched
23 Apr 13			Breached, manually	
29 Jan 14*	7:27	6.8		Closed
27 Feb 14	7:23	6.2		Closed
28 Feb 14			Breached, 26-28 Feb 14, 5.34”	
06 Mar 14	12:16	4.9	Breached, rain same as above	Connected
12 Jun 14	21:13	6.7		Closed
13 Jun 14	21:56	6.7		Closed
11 Jul 14	21:00	7.0		Closed
12 Jul 14	21:46	7.0		Closed
13 Jul 14	22:34	6.7		Closed
10 Aug 14	20:53	6.9		Overwash at high tide

*LA County Lifeguard data was available until June 2013. Data since June comes from observations during water quality sampling events.

**Sand berm connection was open at the time of water quality sampling (5:58 am), but closed when the Lifeguard data was recorded. High tide was at 4:17 am, height was 5.1 ft

6.3.1.2 Site Conditions

At each sampling event, qualitative information concerning site conditions was noted. These included water clarity, color and odor, surface conditions, and presence of foam, debris and trash. Compliance was indicated by an ability to clearly see the bottom, lack of discernable odor, and lack of surface oil or foam (Table 6-3). Table 6-7 summarizes the observations of site conditions and compliance. The two sites in Upper Topanga, Owl Falls (6500 m) and Scratchy Trail (4800 m) had the highest percentage of sample dates where water conditions were not compliant, whereas two Lower Topanga sites, Topanga Bridge (3600 m) and Brookside Drive (1700 m) had the lowest percentage. The percentage of dates when not compliant increased again further downstream at the two sites closest to the PCH and nearby development. Lack of compliance was typically due to poor water clarity or unclear water, and only occasionally due to the presence of an odor, surface oil or foam/bubbles.

Table 6-3 Summary of qualitative water conditions data, Dec 2012- Aug 2014.

Site	Total Dates Sampled	Number Dates not Compliant*	% Not Compliant	Number of dates not compliant				
				Water Clarity (not clear)	Water Color (not clear)	Water Odor Present	Surface Oil Present**	Foam/ Bubble Present**
Topanga Lagoon 0 m (TL)	28	10	36	3	7	5	0	3
Snake Pit – 300 m (SP)	22	10	45	4	3	3	5	0
Brookside Drive- 1700 m (BR)	26	3	12	1	1	0	1	1
Topanga Bridge – 3600 m (TB)	29	4	14	1	1	1	2	0
Scratchy Trail- 4800 m (ST)	21	15	71	9	11	0	1	1
Owl Falls – 6500 m (OF)	19	11	58	3	10	0	0	1

*Each sampling date that was not compliant may be associated with multiple water condition values that are not compliant or compliant. To calculate the percentage of dates not compliant, the number of sampling dates not compliant was used (not the number of water conditions not compliant).

**Surface oil and foam/bubbles could be from biological or non-biological sources.

Impacts from transients, careless visitors, or dumping from RV's were observed throughout the study period. Human, dog and bird feces were observed at various sites and times, but fairly consistently at Topanga Lagoon (Table 6-4). The presence of bird feces at the lagoon, which was mainly gull, was not surprising. Topanga Beach does not permit dogs on the beach. However dogs were observed frequently and their feces were observed occasionally. Human feces were observed on several occasions in the pedestrian underpass below PCH, as well as along the creek (Figure 6-1). Observations of human feces in the underpass often coincided with observations of transient activity. We also documented RV discharge along the shoulder of Topanga Canyon Blvd. (Figure 6-2) that was associated with a strong urine smell, and suspected discharge into the culvert from the shoulder of PCH that connects directly to Topanga Lagoon (Figure 6-3).

Table 6-4 Summary of feces observations by sampling date and location, where H=Human, D=Dog, and B=Bird. (gray boxes indicate transient activity observed).

Date	Topanga Lagoon (TL)	PCH Bridge (HB 0 m)	Snake Pit (SP 300 m)	Brookside Dr. (BR 1700 m)	Topanga Bridge (TB 3600 m)	Scratchy Trail (ST 4800 m)	Owl Falls (OF 6500 m)
19-Dec-12	H,D,B	▨		H			
9-Jan-13	B				▨		
24-Jan-13	H,B						
27-Jan-13	H,B	H					
6-Feb-13	H,B	H					
24-Feb-13	H,B	H					
6-Mar-13	H,B	H					
24-Mar-13	B	▨					
8-May-13	H,B						
1-Jul-13	B						
31-Jul-13	B						
21-Aug-13	B						
20-Nov-13	B		B	▨			
19-Dec-13	B,D				▨		
6-Jan-14	B			▨			
29-Jan-14	B		▨		H		
7-Feb-14	B	▨		▨	H		
20-Feb-14	▨		D	▨			
27-Feb-14	B				H		
6-Mar-14	B						
24-Mar-14	B			▨			H
29-May-14	B	▨					
15-Jul-14	▨						

Figure 6-1 Direct deposit and transient activity under PCH Bridge, 29 March 2013.

Figure 6-2 RV discharge on shoulder of Topanga Canyon Blvd., May 31, 2013

Figure 6-3 RV near culvert at PCH Bridge over Topanga Lagoon

Trash was observed in light abundance (1-10 pieces) fairly regularly at Topanga Lagoon and Topanga Bridge, the two most easily accessible sites, and episodically at the other sites along Topanga Creek (Figure 6-4). Moderate (11-50) and heavy (>50) amounts of trash were observed fairly often at Topanga Lagoon, however, rarely observed in the creek. The majority of the trash observed consisted of discarded plastic, bottles and cans (Figure 6-5). Spray paint cans were routinely picked up and removed from under the Topanga Bridge and Lagoon, two places where tagging is typically observed.

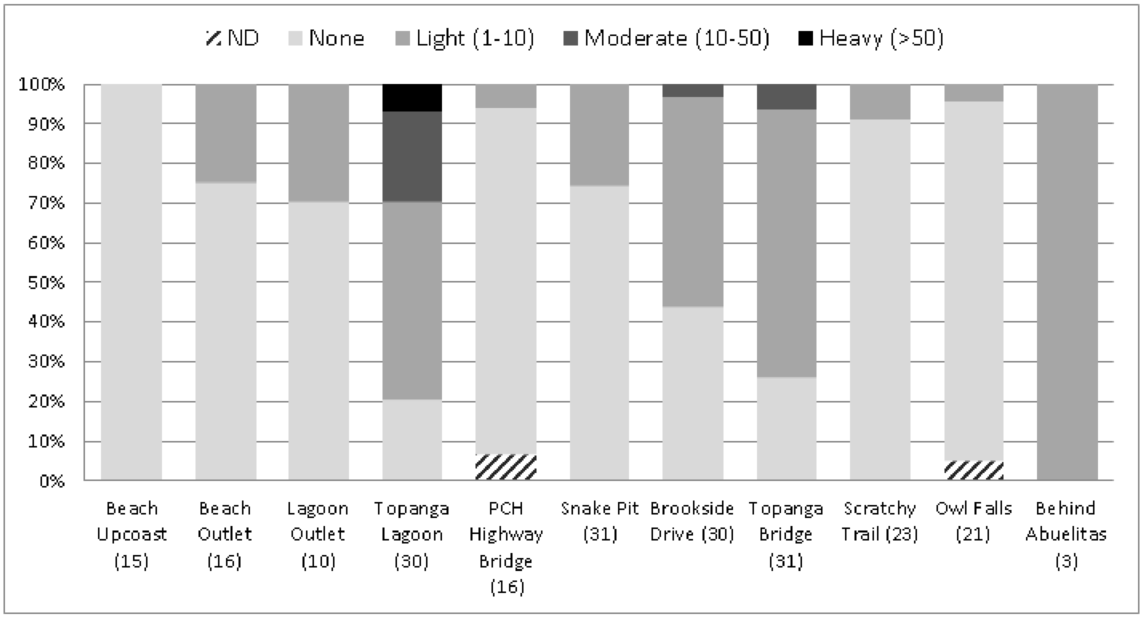

Figure 6-4 Percentage of sampling events when trash was observed and in what abundance at sampling sites along Topanga Creek, Lagoon and Beach between Dec 2012-Aug 2014. Number of dates each site was sampled is in parentheses below site name.

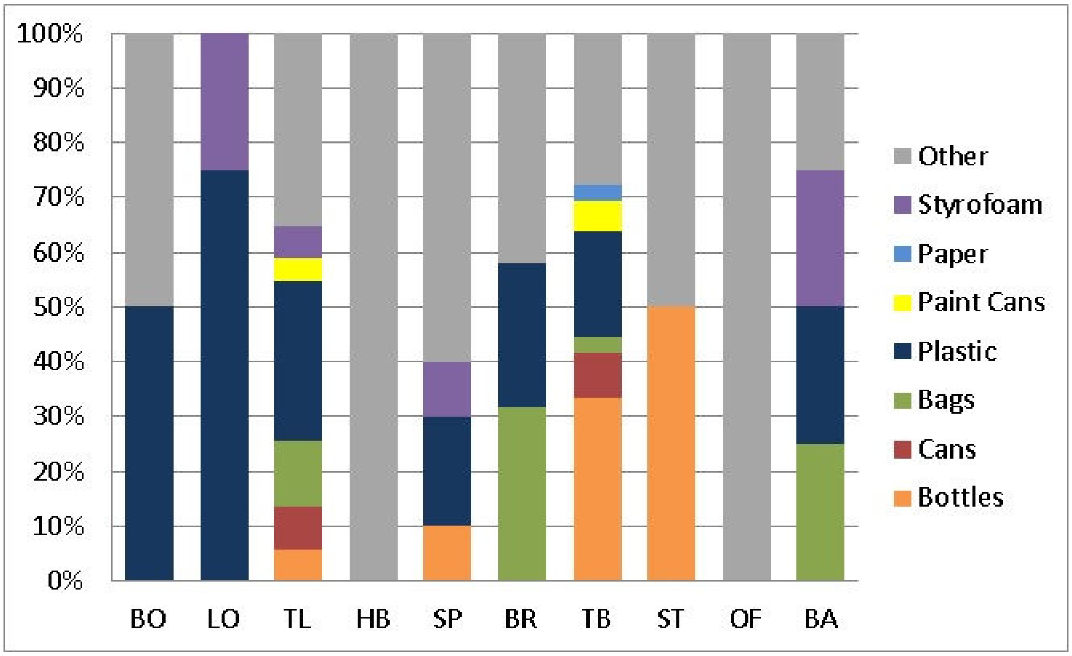

Figure 6-5 Percentage of sampling events where various types of trash were observed. Occurrences and types of trash observed during 31 sampling events from Dec 2012-August 2014.

6.3.1.3 First Flush, Flow and Depth

First flush sampling events occurred on January 24, 2013 and February 27, 2014. These were events where greater than 0.75” of rain fell during a single storm. January 24 was considered first flush for water year 2012-2013 because it had been almost two months since a considerable rainfall event. Data for these two events is presented separately from non-first flush events in the tables below.

There was very little rainfall between Dec 2012 and Aug 2014, which resulted in very low flow conditions, even during rain events (Table 6-5). In fact, the creek never recharged sufficiently to reach continuous base flow. The reach between 400-1650 m connected during a short rain event in January 2013 and late-February to early-March 2014, but otherwise flowed sub-surface with a few pools during rain events. Depth is one of the most variable parameters measured, even though we attempted to measure at the same location each time. Depth is directly related to rainfall, except in Topanga Lagoon, where depth increases when the sand berm is closed, causing a pooling effect. Compared with the flow and depth recorded in 2003-2004, levels were generally much lower (Dagit et al. 2004). For instance in 2003-2004, the lagoon had an average depth of 50 inches versus 17 during this study, and the Topanga Bridge averaged 40 inches versus 8 during this study. Additionally, a slug of sandy sediment continues to accumulate in the lagoon since 2011, and reduce overall depth (Table 6-6).

Table 6-5 Summary of flow (cfs) in Topanga Creek, Dec 2012- Aug 2014.

		First Flush (FF) Events		**Non-FF Events**		
Site	**Total # Dates Sampled**	**01/24/13**	**02/27/14**	**Max Flow (cfs)**	**Min Flow (cfs)**	**Mean Flow (cfs)**
SP (300 m)	30	0.27/3.54*	DRY	0.78	0.00	0.18
BR (1700 m)	21	No data	7.12	0.72	0.00	0.20
TB (3600 m)	26	4.73	3.04	0.84	0.05	0.26
ST (4800 m)	30	No data	2.76	0.69	0.03	0.18
OF (6500 m)	23	No data	2.94	0.41	0.05	0.20

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 Jan 2013. The first set was taken at 13:30, followed by a surge in flow and re-sampling at 14:45. Both data points are presented respectively.

Table 6-6 Summary of water depth (inches) for Topanga Lagoon and Creek sites, Dec 2012- Aug 2014.

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13 Depth (in)**	**02/27/14 Depth (in)**	**Max Depth (in)**	**Min Depth (in)**	**Mean Depth (in)**
TL (0 m)	30	20	14	34 (02/24/13)	7	17
SP (300 m)	21	7.2/11.2*	DRY	10 (08/21/13)	3	7
BR (1700 m)	26	No data	19	20 (05/08/13)	7	13
TB (3600 m)	30	12.4	14	32 (03/06/14)	1	8
ST (4800 m)	23	No data	14	32 (12/19/13)	5	12
OF (6500 m)	21	No data	20	16 (7/31/2013)	2	8

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 Jan 2013. The first set was taken at 13:30, followed by a surge in flow and re-sampling at 14:45. Both data points are presented respectively.

6.3.2 *Chemical Conditions*

6.3.2.1 Water Temperature

Snapshot water temperatures taken in the early mornings using the YSI Model 55 dissolved oxygen meter varied seasonally, but average temperatures were highest in the Lagoon and Snake Pit (300 m). Although Snake Pit (300 m) is fairly well shaded, it is consistently shallow and, throughout the study period, often disconnected from the 1700 m site by an approximate 1000 m stretch through lower Topanga that ran subsurface. Average temperatures throughout the rest of the creek up to town did not vary much, but did increase slightly from lower to upper sites (Table 6-9).

Table 6-7 Summary of water temperature (ºC) in Topanga Lagoon and Creek, Dec 2012- Aug 2014.

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13 Temp (ºC)**	**02/27/14 Temp (ºC)**	**Max Temp (ºC)**	**Min Temp (ºC)**	**Mean Temp (ºC)**
TL (0 m)	30	14.2	12.6	22.5	7.4	16.3
SP (300 m)	21	17/14.3*	DRY	17.9	11.3	15.8
BR (1700 m)	26	No data	11.2	18.9	6.0	12.7
TB (3600 m)	30	10.4	10.6	19.3	6.5	13.4
ST (4800 m)	23	No data	9.3	19.0	8.0	13.6
OF (6500 m)	21	No data	No data	19.1	8.4	13.9

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 Jan 2013. The first set was taken at 13:30, followed by a surge in flow and resampling at 14:45. Both data points are presented respectively.

Water temperature was also monitored in several locations throughout Topanga Creek at 30-minute intervals using Tidbit v2 temperature data loggers (Onset Hobo; Figure 6-6). Data from Ski Pole Pool, a site located at 2000 m, is shown here as it is representative of the creek and has both air and water temperature data associated with it. The endangered southern steelhead (*Oncorhynchus mykiss*) is also typically observed in this location, and monitored consistently. Despite relatively warm air temperatures, especially in Spring 2014, water temperatures in Ski Pole Pool remained below 25ºC throughout the study period. On the low end, water temperatures rarely dropped below 10ºC.

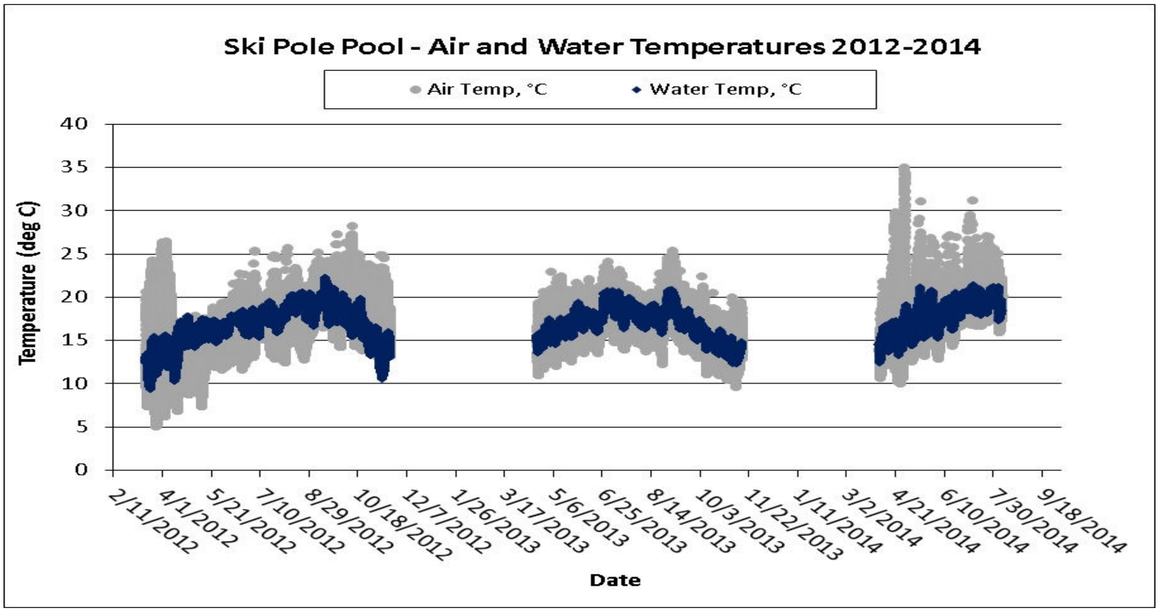

Figure 6-6 Air and water temperatures (ºC) from Onset Hobo Tidbit v2 loggers at Ski Pole Pool (2000 m). Gaps in data are from when hobos were removed during the wet season.

To date, *O. mykiss* have been observed only rarely in Topanga Lagoon and only for short periods of time when they are present. The lagoon, however, is an important habitat for endangered tidewater gobies (*Eucyclogobius newberyii*). *E. newberyii* have a wider temperature and dissolved oxygen tolerance than *O. mykiss,* and, despite the higher average temperatures in the lagoon, thrive there and approximately 200 meters upstream (RCDSMM, *unpublished data*). Water temperature was monitored in upper Topanga Lagoon (50 m above PCH bridge) at 30-minute intervals using a Tidbit v2 logger between Dec 2013 and Aug 2014. Additionally, water temperature and dissolved oxygen levels were monitored continuously using a YSI 6600 water quality probe in lower Topanga Lagoon (below PCH bridge) by Southern California Coastal Water Research Project (SCCWRP) between November 2013 and June 2014 (Figure 6-7).

Water temperatures were mostly comparable in the lower and upper lagoon except for during a period of time from April to June 2014 when temperatures were considerably higher in the lower lagoon. This could be a result of reduced water depth in the lagoon following the late-February storm and associated sedimentation accompanied by high air temperatures during that time. Dissolved oxygen levels in the lower lagoon were consistently over 6 mg/L from Nov 2013 to early Mar 2014 prior to that storm. The resulting sedimentation following the storm and perhaps a glitch in the probe caused a lapse in data from early March to April 2014. The probe appeared to start working properly again in late-April and showed variable, and generally low DO levels until the end of May. Readings then became more consistent, however remained lower than before the Feb storm. DO readings were taken throughout the creek as well during regular sampling events and are discussed further in Chapter 6, section 6.3.2.2.

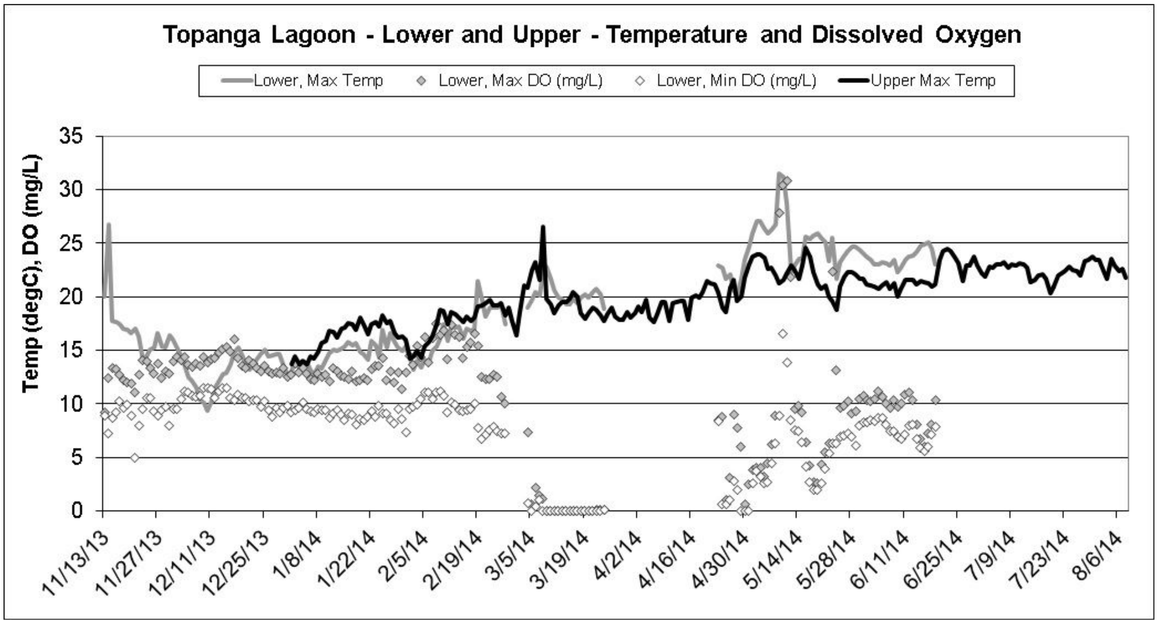

Figure 6-7 Daily maximum water temperatures (ºC), maximum and minimum dissolved oxygen (mg/L) levels of the lower (below PCH bridge) Topanga Lagoon, as well maximum temperatures in the upper (50 m above PCH bridge) Topanga Lagoon, Nov 2013 to Aug 2014. (Temperature and DO data for lower lagoon courtesy of the Southern California Coastal Water Resources Project)

6.3.2.2 Dissolved Oxygen

Dissolved oxygen (DO) levels naturally vary during the day, and are typically highest in the middle to late in the day when plants and algae are photosynthesizing, and lowest in the early morning, after plants and algae have been respiring throughout the night.

Samples should be representative of lowest DO levels as they are collected just before, at, or just after dawn. Every attempt was made to collect samples within the same time frame at each sampling event, thus reducing the variability related to normal diurnal fluctuations. The Los Angeles Regional Water Quality Control Plan (LARWQCB 1994 with 2011 updates) has a water quality objective of greater than 5 mg/l for any single determination in cold water, and greater than 7 mg/l for all waters, except where natural conditions cause lesser concentrations.

Snake Pit (300 m) had by far the lowest DO levels overall (Table 6-7). This site is fairly well shaded and the least variable over time (Figure 6-8), but was disconnected from the upper creek, or stagnant for much of the study period. The other site with lower levels of DO was Owl Falls (6500 m), located at the upper end of the study reach and although the minimum DO recorded was under 5 mg/L, the average was above 5 mg/L. Brookside Drive (1700 m) had the highest average DO, followed by Topanga Lagoon.

Table 6-7 Summary of dissolved oxygen (mg/L and % saturation) in Topanga Lagoon and Creek, Dec 2012- Aug 2014.
(Water Quality Objective >5 mg/L)

		First Flush (FF) Events		**Non-FF Events**		
Site	**Total # Dates Sampled**	**01/24/13 mg/L (%sat)**	**02/27/14 mg/L (%sat)**	**Max DO mg/L (%sat)**	**Min DO mg/L (% sat)**	**Mean DO mg/L (%sat)**
TL (0 m)	30	10.2 (100.4)	9.4 (95.0)	11.8 (127.7)	1.4 (14.2)	8.1 (85.5)
SP (300 m)	21	2.6/8.5 (83.4)*	DRY	7.0 (64.5)	2.2 (23)	4.4 (44.3)
BR (1700 m)	26	No data	10.0 (97.3)	11.2 (100.1)	5.3 (54.3)	8.2 (77.8)
TB (3600 m)	30	11.03 (99.2)	10.3 (98.7)	10.5 (92.9)	5.6 (60.9)	7.9 (75.1)
ST (4800 m)	23	No data	9.7 (93.3)	10.9 (92.3)	5.7 (52.5)	7.9 (75.6)
OF (6500 m)	21	No data	8.9 (84.0)	9.3 (81)	2.6 (20.7)	6.1 (57.5)

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 Jan 2013. The first set was taken at 13:30, followed by a surge in flow and resampling at 14:45. Both data points are presented respectively. % saturation data was only taken at 14:45.

6.3.2.3 pH

pH levels throughout the creek and lagoon remained fairly consistent and did not fluctuate significantly. Most aquatic species prefer a pH range between 6.5-9 in freshwater systems. Although average pH (7.6-8.2) was slightly on the alkaline side, even maximum recorded levels (7.9-8.5) remained within the tolerance limit range for most aquatic species (Table 6-8). Snake Pit (300 m) again stands out with the lowest average pH.

Table 6-8 Summary of pH in Topanga Lagoon and Creek, Dec 2012- Aug 2014.
(Water Quality Objective 6.5-9.0)

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13 (pH)**	**02/27/14 (pH)**	**Max pH**	**Min pH**	**Mean pH**
TL (0 m)	30	8.00	8.53	8.5	7.6	8.2
SP (300 m)	21	7.37/7.94*	DRY	7.9	7.4	7.6
BR (1700 m)	26	No data	8.31	8.4	7.7	8.2
TB 3600 m)	30	8.43	8.3	8.4	7.8	8.2
ST (4800 m)	23	No data	8.4	8.5	7.5	8.2
OF (6500 m)	21	No data	8.14	8.2	7.1	7.9

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 January 2013. The first set was taken at 13:30, followed by a surge in flow and resampling at 14:45. Both data points are presented respectively.

6.3.2.4 Water Temperature, pH, and Dissolved Oxygen

Figure 6-8 shows water temperature, pH and dissolved oxygen for each site for the duration of study. See Appendix A for graphs with more detail. Snake Pit was dry from November through February 2014 (first flush) and started to dry up in early August again. Brookside Drive was dry for the months of September and October 2013, and August 2014.

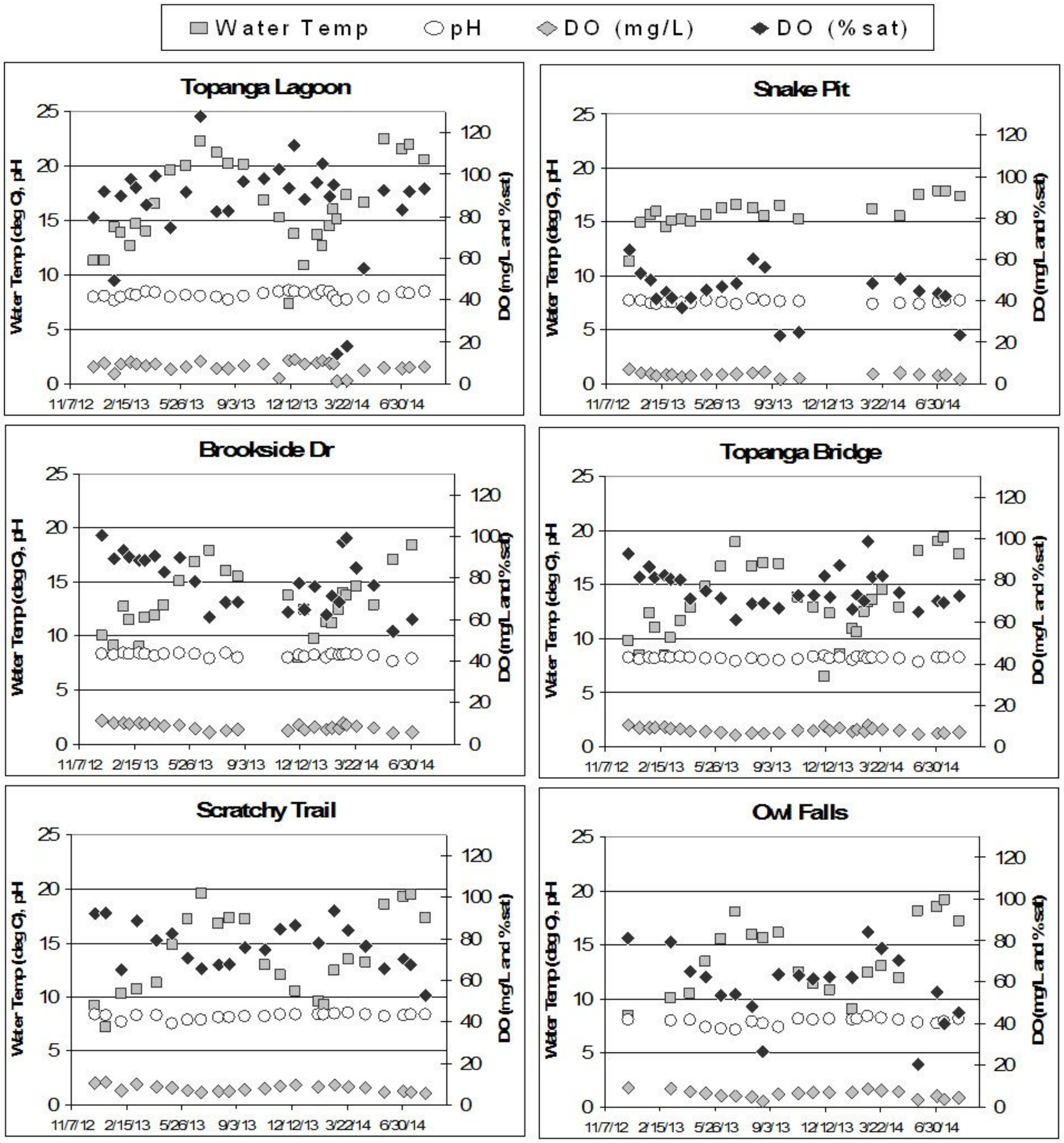

Figure 6-8 Water temperature (ºC), pH, and dissolved oxygen (mg/L, %sat) for all sites, Dec 2012-Aug 2014. (Dissolved Oxygen (DO) is on the right axis).

6.3.2.5 Salinity

Surface salinity levels in Topanga Lagoon were mostly low, with a few higher saline events observed when overwash or tidal exchange occurred (Table 6-9). Salinity levels in Topanga Creek never exceeded 3 parts per thousand (ppt), and, on average, were generally less than 1.

Table 6-9 Summary of salinity (ppt) in Topanga Lagoon and Creek, Dec 2012- Aug 2013

		First Flush (FF) Events		Non-FF Events		
Site	Total # Dates Sampled	01/24/13 (ppt)	02/27/14 (ppt)	Max Salinity (ppt)	Min Salinity (ppt)	Mean Salinity (ppt)
TL (0 m)	30	2	2	5	0	1.5
SP (300 m)	21	0.5/0.5*	DRY	3	0	0.8
BR (1700 m)	26	No data	0	2	0	0.6
TB 3600 m)	30	1	0	2	0	0.4
ST (4800 m)	23	No data	1	3	0	0.9
OF (6500 m)	21	No data	1	3	0	0.9

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 Jan 2013. The first set was taken at 13:30, followed by a surge in flow and resampling at 14:45. Both data points are presented respectively.

6.3.2.6 Conductivity

Perhaps related to the slightly higher salinity levels of the lagoon, conductivity was consistently higher there than throughout the rest of the creek, which remained fairly constant (Table 6-10). At standard temperatures, conductivity is a measure of the number of dissolved ions in the water, and is recorded as µS/cm (microsiemens per centimeter). Ranges are usually from 0.5-3.0 µS/cm for distilled water, with potable water ranging from 30-1500 µS/cm and seawater up to 53,000 µS/cm. No specific water quality range is included in the Water Quality Control Plan Los Angeles Region. This measurement is an indirect way to evaluate the amount of dissolved salts in the water that are conductors. In conjunction with pH and salinity, conductivity is used to evaluate inputs from groundwater sources or sewage.

Again, Snake Pit (300 m) stood out among the other creek sites, having a generally higher conductivity level than the sites further upstream. Snake Pit is located in what historically would have been part of the upper estuary, which could be contributing to the higher conductivity.

Conductivity was also measured for the ocean sites. These levels did not vary from site to site along the beach front, remaining between 46,600-53,600 µS/cm, which is typical for marine waters.

Table 6-10 Summary of Conductivity Topanga Lagoon and Creek Dec 2012- July 2013

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13 (µS/cm)**	**02/27/14 (µS/cm)**	**Max (µS/cm)**	**Min (µS/cm)**	**Mean (µS/cm)**
TL (0 m)	30	1805	2000	10250	2000	3576
SP (300 m)	21	1789/1305*	DRY	2200	1673	1890
BR (1700 m)	26	No data	1400	1920	1290	1590
TB 3600 m)	30	1317	1210	1690	1140	1421
ST (4800 m)	23	No data	1200	2380	1200	1521
OF (6500 m)	21	No data	1210	1780	1210	1410

*Two sets of data were taken at Snake Pit (300 m) during the first flush event on 24 Jan 2013. The first was taken at 13:30, followed by a surge in flow and resampling at 14:45 (both points are presented respectively).

6.3.2.7 Nitrate–N

The nitrate levels in Topanga Lagoon and creek were consistently well below the 1 ppm threshold for concern for aquatic species (EPA 2012; Table 6-11). Only one time did nitrate-N levels exceed 1ppm, and that was at Owl Falls, the closest site to town, during a first flush event. The standard for drinking water is <10 ppm. Levels of nitrate greater than 3.5 ppm are thought to contribute to increased algal production and eutrophication in Southern California streams (Luce and Abramson 2005). Natural background readings vary depending on underlying geologic conditions, but can range from 0.0- 0.08 ppm (EPA 2012). The pending TMDL limit for Malibu Creek is <1 ppm (EPA 2012). Compared to both maximum and average levels documented at Topanga Lagoon (max=0.87, mean=0.14) and Topanga Bridge (max=0.84, mean=0.15) in 2003-2004, current levels are even lower and consistent throughout the creek and lagoon.

Table 6-11 Summary of nitrate-N (ppm) in Topanga Lagoon and Creek sites, Dec 2012- Aug 2014. Water Quality target <1 ppm.

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13 (ppm)**	**02/27/14 (ppm)**	**Max (ppm)**	**Min (ppm)**	**Mean (ppm)**
TL (0 m)	30	0.01	0.26	0.18 (12/09/13)	0	0.02
SP (300 m)	21	0.01	DRY	0.08 (01/09/13)	0	0.01
BR (1700 m)	26	0	0.02	0.11 (01/09/13)	0	0.02
TB (3600 m)	30	0	0.19	0.25 (03/06/13)	0	0.01
ST (4800 m)	23	No data	0.14	0.07 (03/06/13)	0	0.01
OF (6500 m)	21	No data	1.14	0.21 (03/06/13)	0	0.06
Dix Creek	1	No data	0.97	-	-	-

6.3.2.8 Nitrite–N

Nitrite-N can have serious health effects for infants, and is the cause of the blue baby syndrome (EPA 2014). The tolerance levels for aquatic species are not well documented. The target for nitrite–N is 1 ppm (LARWQCB 1994 with 2011 updates). All sites within Topanga Lagoon and creek are consistently well below that threshold.

Table 6-12 Summary of nitrite-N (ppm) in Topanga Lagoon and Creek sites, Dec 2012- Aug 2014. (Water Quality target is < 1 ppm)

		First Flush (FF) Events		**Non-FF Events**		
Site	**Total # Dates Sampled**	**01/24/13**	**02/27/14**	**Max (ppm)**	**Min (ppm)**	**Mean (ppm)**
TL (0 m)	30	0	0	0.05 (04/10/13)	0	0.01
SP (300 m)	21	0.03	DRY	0.17 (04/10/13)	0	0.02
BR (1700 m)	26	0.03	0	0.04 (02/06/13, 03/24/13)	0	0.01
TB (3600 m)	30	0.01	0	0.05 (02/06/13)	0	0.01
ST (4800 m)	23	No data	0	0.09 (04/10/13)	0	0.01
OF (6500 m)	21	No data	0	0.05 (04/01/13, 06/05/13)	0	0.01
Dix Creek	1	No data	0.1	-	-	-

6.3.2.9 Ammonia -N

Although the maximum levels of ammonia–N observed at Snake Pit (300 m), Brookside Drive (1700 m) and Topanga Bridge (3600 m) were somewhat high, these levels were observed in conjunction with transient and recreational activity at those locations (Table 6-13). The high average observed at Brookside Drive is difficult to explain, as transient activity there has been episodic rather than chronic, although there was an observed wet spot and associated urine smell on Topanga Canyon Boulevard near Brookside Drive where an RV was apparently emptying its waste. The most curious result was the levels of ammonia observed at Scratchy Trail (4800 m), which should have the least amount of anthropogenic input. There have been a few encampments observed upstream, but none in that vicinity. Average levels were well below the 0.4 ppm target for freshwater systems but it is curious that this is the only variable that increases as water moves downstream from town. The most common sources of ammonia –N in freshwater systems are human effluent and animal wastes. Most aquatic species are quite sensitive to increased levels of ammonia, with toxicity occurring between 1-25 ppm. The Water Quality Control Plan Los Angeles Region utilizes the EPA pH adjusted range of 2.5 – 10.5 ppm.

Table 6-13 Summary of ammonia-N (ppm) in Topanga Lagoon and Creek, Dec 2012- Aug 2014.
(Water Quality target < 0.4 ppm)

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13**	**02/27/14**	**Max (ppm)**	**Min (ppm)**	**Mean (ppm)**
TL (0 m)	30	0.12	0.42	0.70 (02/07/14)	0	0.06
SP (300 m)	21	0.20	DRY	1.95 (12/19/12)	0	0.19
BR (1700 m)	26	0.02	0.21	3.91 (06/05/13)	0	0.27
TB (3600 m)	30	0.03	0.28	1.42 (05/08/13)	0	0.11
ST (4800 m)	23	No data	0.25	0.69 (02/07/14)	0	0.12
OF (6500 m)	21	No data	0.53	0.32 (07/15/14)	0	0.07
Dix Creek	1	No data	0.60	-	-	-

6.3.2.10 Orthophosphate

Maximum orthophosphate levels exceeded the target of 0.10 ppm for all locations throughout Topanga Lagoon and Creek at some point (Table 6-14. Average levels also exceeded the target limit at Brookside Drive (1700 m), Scratchy Trail (4800 m) and Owl Falls (6500 m). However, these levels are still under those documented at Topanga Lagoon (max=0.37, mean=0.11) and Topanga Bridge (max=0.47, mean=0.10) observed in 2003-2004 (Dagit et al. 2004). Common sources of levels exceeding 0.65 ppm in freshwater include organic elements from septic systems, graywater systems and inorganic sources like fertilizers and soaps from detergents. Natural readings range from 0.0-0.65 ppm. The higher levels at Owl Falls make sense, as this site is closest to human inputs such as graywater. The levels at Brookside Drive and Topanga Bridge appear related to transient activity, but the level at the more remote Scratchy Trail is unclear. It is possible that the orthophosphate is dissipating and being diluted as it moves downstream from Owl Falls, but incompletely.

Table 6-14 Summary of orthophosphate (ppm) in Topanga Lagoon and Creek, Dec 2012- Aug 2014.
(Water Quality target is < 0.10 ppm)

		First Flush (FF) Events		Non-FF Events		
Site	**Total # Dates Sampled**	**01/24/13**	**02/27/14**	**Max (ppm)**	**Min (ppm)**	**Mean (ppm)**
TL (0 m)	30	0.16	0.37	0.93 (3/6/14)	0.00	0.07
SP (300 m)	21	0.10	DRY	0.22 (9/18/13)	0.02	0.08
BR (1700 m)	26	0.04	0.27	0.51 (05/08/13)	0.02	0.09
TB (3600 m)	30	0.06	0.19	0.20 (7/2/14)	0.01	0.07
ST (4800 m)	23	No data	0.32	0.30 (7/31/13)	0.02	0.13
OF (6500 m)	21	No data	0.87	0.49 (1/29/14)	0.00	0.19
Dix Creek	1	No data	0.83	-	-	-

6.3.2.11 Turbidity

The amount of suspended particles, phytoplankton, pollutants, and other materials is measured as turbidity. Not only does turbidity affect water clarity, it can also increase heat absorption and impair breathing and foraging of aquatic animal species (Yamamoto 2010). Other than a few incidents of high turbidity observed at Topanga Lagoon and Owl Falls (6500 m), most of the sites in Topanga creek are below the drinking water standard of 5 NTU (Table 6-15). However, as the summer progressed in 2013 and 2014, visibility in the mid-upper reaches of the creek between Topanga Bridge (3600 m) and Owl Falls (6500 m) decreased markedly. These locations are also where there has been an explosive population increase of introduced red swamp crayfish. Turbidity levels at Topanga Lagoon (max = 44.7 NTU, mean = 2.53 NTU) and Topanga Bridge (max = 35.6 NTU, mean = 1.53 NTU) were significantly higher in 2003-2004 than they are today. The higher NTU levels at Scratchy Trail (4800 m) could well be a result of crayfish disturbance, as this site is small, confined and full of crayfish.

The Los Angeles Region Basin Plan objective for turbidity is a mix of numeric and narrative: “The secondary drinking water standard for turbidity is 5 NTU. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in natural turbidity attributable to controllable water quality factors shall not exceed the following: where natural turbidity is between 0 and 50 NTU, increases shall not exceed 20%; where natural turbidity is greater than 50 NTU, increases shall not exceed 10%.”

Table 6-15 Summary of Turbidity (NTU) in Topanga Lagoon and Creek, Dec 2012- Aug 2014. Drinking water standard is less than 5 NTU.

		First Flush (FF) Events		**Non-FF Events**		
Site	**Total # Dates Sampled**	**01/24/13**	**02/27/14**	**Max (ppm)**	**Min (ppm)**	**Mean (ppm)**
TL (0 m)	30	0.36	35.1	10.31 (03/24/14)	0.13	2.86
SP (300 m)	21	0	DRY	9.69 (08/11/14)	0	1.41
BR (1700 m)	26	0	29.3	2.02 (05/29/14)	0	0.37
TB (3600 m)	30	0.06	18.1	2.31 (03/06/13)	0	0.57
ST (4800 m)	23	No data	38.2	4.63 (07/31/13)	0.13	1.15
OF (6500 m)	21	No data	12	5.14 (03/06/13)	0.17	0.92
Dix Creek	1	No data	18.6	-	-	-

6.3.3 Biological Conditions

6.3.3.1 Nutrients and algae among sites

Figure 6-9 shows all nutrient and algae levels at all sites throughout the study period (see Appendix A for more details). Levels of all nutrients and algae were generally low with only a few spikes at during first flush events. Some nutrients, especially orthophosphates were above the water quality objective for several of the sites.

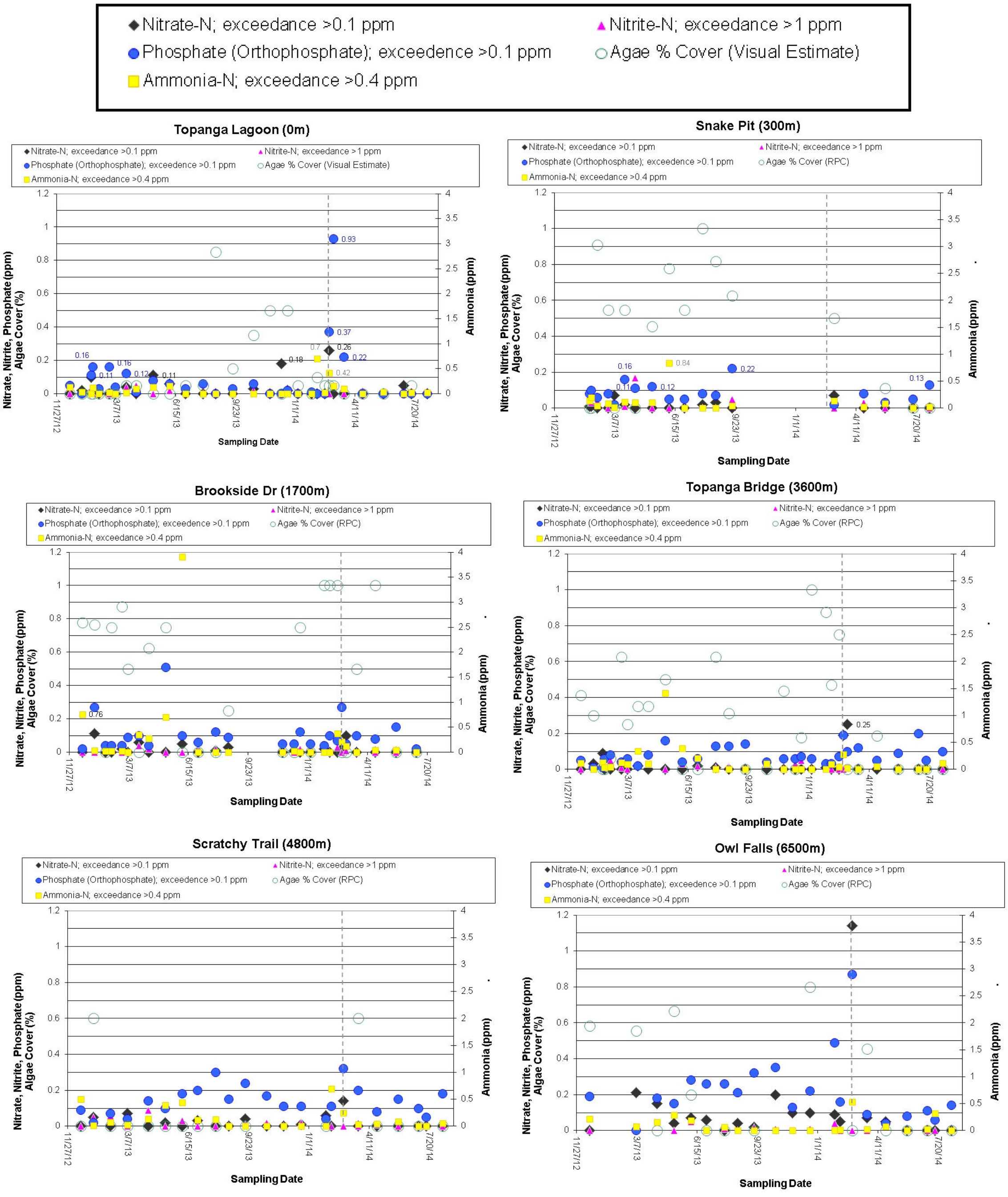

Figure 6-9 Nutrients and algae at all sites, Dec 2012-Aug 2014.

6.3.3.2 Algae

In order to track the presence and abundance of algae in the lagoon and creek over time, two types of algae data were taken during each sampling event – a visual estimate of percent cover and random point contact method data concurrently with flow and depth. Algal types and percent cover were surveyed at creek sites (Snake Pit (300 m), Brookside Drive (1700 m), Topanga Bridge (3600 m), Scratchy Trail (4800 m), Owl Falls (6500 m)) during each sampling date using the RPC method. Using the same transect where flow was measured, random points were generated, and presence/absence and type of algae was recorded at each point. If algae were present, the type of algae was recorded. *Cladophora* sp. and *Enteromorpha* sp. were the only species of algae observed in Topanga Creek during this sampling period. If an alga was observed, but the type was not known, it was recorded as "other" or "unknown." Voucher specimens of unknown algae were collected for future identification. If algae were absent from the point, the substrate was recorded as bare substrate (sand, pebble, cobble, rock, boulder was noted), biological debris (leaves, sticks), aquatic or terrestrial plants (if type was known, it was recorded), or diatoms.

For Topanga Lagoon, percent cover of algae was visually estimated for the lagoon as a whole, with the observations generally made from the bank above or from the east bank, which provided a good view of the whole lagoon area south of the PCH bridge.

Table 6-16 outlines the types of algae observed in Topanga Lagoon and creek from December 2012 to August 2014. *Macrocystis* was observed floating (unattached) in Topanga Lagoon, especially following high tide/overwash or breach events. *Cladophora* sp. was observed in Topanga Lagoon occasionally as well. *Cladophora sp*. was also observed at Snake Pit, Topanga Bridge and Owl Falls. *Enteromorpha sp*. was observed at Owl Falls and Snake Pit.

Table 6-16 Algal species observed in Topanga Lagoon and Creek during sampling events December 2012 to August 2014.

	ALGAE TYPE		
Location	*Cladophora* sp.	*Enteromorpha* sp.	*Macrocystis pyrifera*
Topanga Lagoon	X		X
Topanga Creek	X	X	

In general, the percent cover of algae was low (<20%) for all sampling dates and all sites (see Figure 6-10). Snake Pit (300 m) had the highest percent cover of algae recorded, 78% cover of *Enteromorpha* sp. on June 5, 2013. This could be contributing to the low dissolved oxygen levels at this location. Brookside Drive (1700 m) had the lowest percent cover of algae, with no algae recorded during any sampling event. The substrate at

Brookside Drive (1700 m), however, was covered with a layer of diatoms almost 40% of the time.

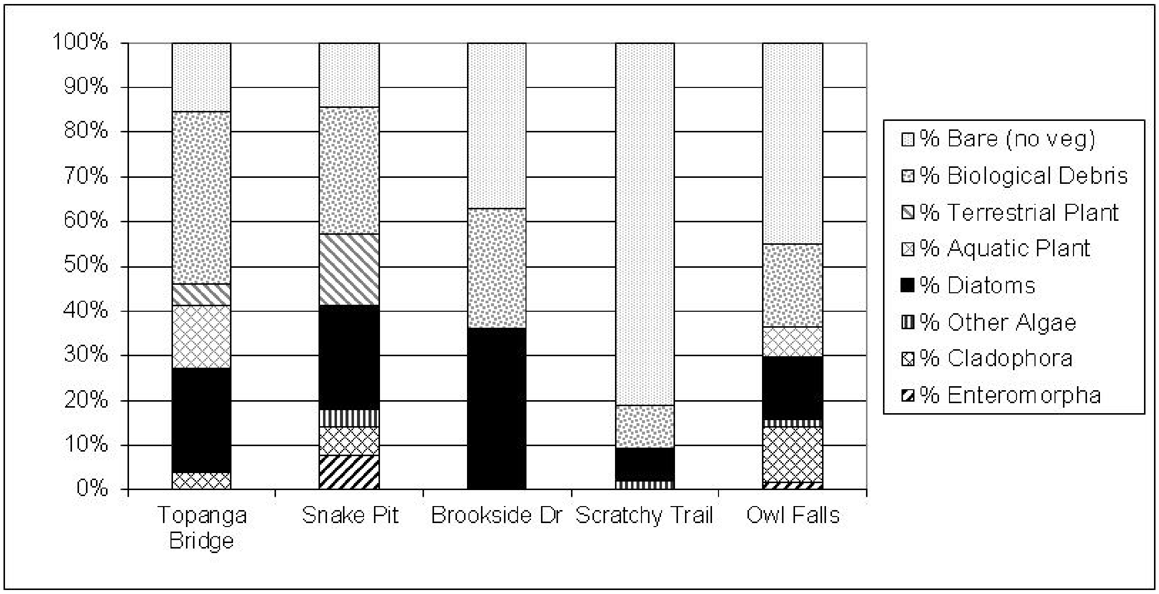

Figure 6-10 Summary of the percent cover of algae and other substrate types at each site Dec 2012-Aug 2014.

On average, Snake Pit (300 m) had about 18% cover algae, Brookside Drive (1700 m) had 0%, Topanga Bridge (3600 m) had less than 5%, Scratchy Trail (4800 m) had 3.2%, and Owl Falls (6500 m) had slightly less than 18%. Owl Falls (6500 m) is the site closest to the town of Topanga, and Snake Pit (300 m) and Topanga Bridge (3600 m) are also sites that are frequented by humans, and potentially dogs or other animals.

6.3.4 *Stream continuum and spatial correlations between nutrients and FIB*

It was hypothesized that natural processes are removing anthropogenic inputs from the water in the creek as it flows from town to the lagoon; therefore we looked at nutrient levels from Owl Falls (OF), the site closest to town, to the lagoon (Figure 6-11). Nitrate and orthophosphate were the highest at Owl Falls. Nitrate levels dropped dramatically from Owl Falls to Scratchy Trail (4800 m), and stayed at about the same level to the Lagoon (TL), where it increased. Orthophosphate levels dropped as well between Owl Falls and Scratchy Trail, and continue to drop further downstream at Topanga Bridge (TB, 3600 m), go back up again at Brookside Drive (BR, 1700 m), and drop again to TL. Nitrite levels were generally low throughout the creek, with the highest average of 0.017 ppm at Snake Pit (300 m). Ammonia was highest at BR, and dropped downstream of there. At sites above BR, ammonia levels were lower than at BR and SP, and OF and TL had the lowest overall ammonia levels.

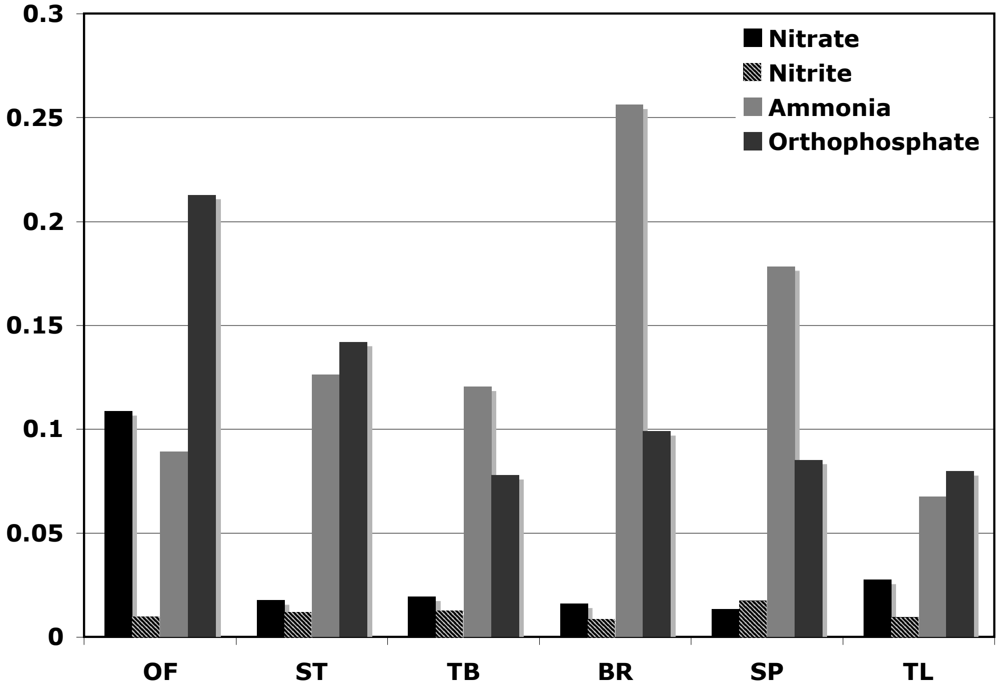

Figure 6-11 Average nutrient levels at each site, from the site closest to town (Owl Falls, 6500 m) to the lagoon, Dec 2012-Aug 2014.

A total of 17 variables were analyzed including FIB, physical and chemical parameters across all sites. This analysis showed a fairly high correlation between nitrate and enterococcus (Pearson's r correlation coefficient = 0.83), and a slight correlation between orthophosphate and enterococcus (0.58) and nitrate (0.60). When analyzed by site (Appendix A), FIB was frequently correlated with orthophosphate, turbidity, flow, nitrate and orthophosphate depending on the site. Many of the FIB values correlated highly (>0.95) with flow and turbidity, especially at the upstream sites. Furthermore, the number of correlated variables decreased from upstream to downstream, especially Owl Falls, where flow, turbidity, orthophosphate, nitrate, ammonia, and all three FIB values are highly correlated (Table 6-17).

Summary of variables with correlation coefficients greater than ±0.70 of the 17 variables analyzed for each site. Coefficient values r>0.9 are highlighted.

Table 6-17 Summary of variables with correlation coefficients greater than ±0.70 of the 17 variables analyzed for each site. Coefficient values r>0.9 are highlighted.

Site	Variable 1	Variable 2	Pearson’s r
TL (0 m)	turbidity	phosphate	0.74
SP (300 m)	EC	TC	0.79
	DO mg/L	turbidity	0.87
	DO %	turbidity	0.82
	conductivity	turbidity	0.75
	conductivity	temp	0.71
	Depth	DO mg/L	0.78
BR (1700 m)	ENT	EC	
	turbidity	EC	0.96
	“	ENT	0.76
	flow	EC	0.96
	“	turbidity	0.99
TB (3600 m)	EC	TC	0.74
	ENT	TC	0.79
	turbidity	TC	0.61
	depth	nitrate	0.76
	depth	turbidity	0.79
	DO	flow	0.71
ST (4800 m)	phosphate	TC	0.77
	turbidity	TC	0.81
	“	EC	0.99
	“	EN	0.99
	“	nitrate	0.74
	flow	EC	0.96
	“	ENT	0.94
	“	nitrate	0.73
	“	turbidity	0.97
OF (6500 m)	ENT	EC	0.99
	nitrate	EC	0.96
	“	ENT	0.96
	ammonia	EC	0.72
	phosphate	TC	0.71
	“	EC	0.79
	“	ENT	0.79
	“	nitrate	0.78
	turbidity	TC	0.75
	“	EC	0.91
	“	ENT	0.90
	“	nitrate	0.95
	flow	TC	0.74
	“	EC	0.98
	“	ENT	0.98
	“	nitrate	0.97
	”	phosphate	0.76
	“	turbidity	0.93

In order to determine whether there were relationships among sites, we tested for correlations between nutrients, FIB, water temperature and dissolved oxygen. Raw data was averaged over time for each site, and mean site data were compared using regression analyses. Only three pairs of variables were significantly spatially correlated. *E. coli* and ammonia were positively correlated ($R^2=0.65$, $P=0.002$, $df=11$), such that, on average, sites with high levels of *E. coli* also had high levels of ammonia. Enterococcus and ammonia were also positively correlated ($R^2=0.50$, $P=0.01$, $df=11$), and nitrite and dissolved oxygen were marginally significantly correlated in a negative direction ($R^2=0.60$, $P=0.07$, $df=5$), such that sites with high levels of nitrite, on average, had low levels of dissolved oxygen.

6.4 QA/QC Protocols

This section is an overview of the quality assurance/quality control measures taken to assure quality data is being collected as well as disseminated. See Appendix G. for the complete Topanga Source ID Study Quality Assurance/Quality Control Plan (April 2013) which provides all details and was reviewed and approved by the TAC. QA/QC includes measures to ensure the accuracy, precision and completeness of all data collected. These standards of practice were implemented throughout the study.

6.4.1 Accuracy and Precision

a. Equipment Calibration

In-situ water quality testing equipment (YSI 55 DO meters, Oakton pH meters, Oakton conductivity meters, and refractometers) were calibrated before each sampling event. The membranes and solution in the DO meters were checked as well and replaced as needed.

b. Training

A training was held at the beginning of the study in December 2012, as well as June and October 2013 to teach all scientists and volunteers how to use, calibrate and maintain the water quality testing equipment, as well as how to properly collect nutrient, bacteria samples, flow and algae data. New scientists and volunteers that did not attend the training were always partnered with experienced people to avoid collecting inaccurate data. Refer to Appendix G for more information on training requirements.

c. Chain of custody and Data sheets

Data sheets and Chain of custody (COC) forms were used to document sample collection, processing, and storage. Lab notebooks were used to document PCR/qPCR analyses.

Although this data is not being used in a regulatory setting, documenting who has physical control of each sample at ALL TIMES was a standard operating procedure. The name and times need to be correct for each step of the process.

Time and Name of person who collected the sample
Time and Name of the person who transports the sample to the lab/RCDSMM
Time and Name of the person who fixes or manipulates the sample for testing
Time and Name of the person who reads the results
Time and Name of the person who enters the data
Time and temperature of ice chest where samples being stored prior to fixing.

All COC forms were compiled in both an electronic and hard copy file at the RCDSMM. All field data forms are also archived at the RCDSMM in chronological order. See Appendix G for samples of data sheets and forms, and for more information on documentation and record keeping.

d. Data Management

Data was entered into an excel spreadsheet as soon as possible following each collection event, and as of July 2013, linked to an access database. Having the data in an access database made it easy to export tables and summary results, which were then used to make graphs or figures. The data transfer from excel to access was checked by one person to verify accurate data was transferred. In the field, data sheets were checked by the lead scientists immediately following data collection, and data entry was checked again when making graphs or tables (can check for outliers).

Furthermore, the Project Manager/Principal Investigator reviewed and validated data against the Project's defined objectives and standard operating procedures in summer 2013, and prior to preparing the final report. If any problems with sampling and analysis were identified, these issues were addressed immediately and methods modified to ensure that data quality objectives are being met. Modifications to monitoring require edits to the approved QA/QC Plan. Only data that have been validated and qualified, as necessary, were entered into the applicable database.

e. Completeness

Since different sites had different sampling events and effort (Tables 6-18 to 6-20) summarizes what type of data was collected for each sampling site (for Beach Upcoast (BU), there were a total of 12 dates where FIB and marker data was collected, some water quality information (temperature, salinity/conductivity) but not nutrients).

Table 6-18 Summary of Sampling Site Completeness for FIB and markers.

Site Name	Total Possible Dates	Total TC/EC/ENT	Total HF gene marker	Total BH gene marker	Total Gull marker	Total Dog marker	Missing Data Points/ Total	% Complete
Beach Upcoast (BU)	38	37/37/ 38	4	5	28	27	90/266	66.2%
Beach Outlet (BO)	48	46/46/ 48	8	8	39	34	107/336	68.2%
Lifeguard Station Beach (LG)	28	27/27/ 28	3	0	22	15	74/196	62.2%
Lagoon Outlet (LO)	18	18/18/ 18	5	6	18	15	28/126	77.8%
Topanga Lagoon (TL)	44	43/43/ 44	8	13	41	28	88/308	71.4%
PCH Bridge (0 m) (HB)	40	38/38/ 39	3	6	33	23	100/ 280	64.3%
Lifeguard Station Septic (LS)	9	9/9/9	8	8	0	1	19/63	69.8%
Snake Pit 300 m (SP)	*32	32/32/ 32	0	3	5	6	114/224	49.1%
Brookside Drive 1700 m (BR)	**28	28/28/ 28	2	2	2	3	103/196	47.4%
Topanga Bridge 3600 m (TB)	38	37/37/ 37	4	6	6	6	127/266	52.3%
SIPP SITES								
Scratchy Trail 4800 m (ST)	24	24/24/ 24	3	1	1	1	90/168	46.4%
Owl Falls 6500 m (OF)	26	26/26/ 26	13	8	1	7	75/182	58.8%
Falls Drive (FD)	2	2/2/2	1	1	0	0	6/14	57.1%
Behind Abuelita's (BA)	9	7/7/9	2	3	0	1	34/63	46.0%

*SP dry during 9 sampling events: 11/20,13, 12/9/13, 12/19/13, 1/6/14, 1/29/14, 2/7/14, 2/20/14, 2/27/14, 3/24/14. (2/7/24 was first flush).

**BR dry during 4 sampling events: 9/18/13, 10/23/13, 7/15/14, 8/11/14.

Table 6-19 Summary of Sampling Site Completeness for In-situ data, 12/19/12-08/11/14

Site Name	Total Possible Dates	Total Water Temp	Total Salinity	Total DO (mg/L)	Total pH	Total conductivity	Missing Data Points/ Total	% Completeness
Topanga Lagoon (TL)	30	30	30	30	30	29 (07/31/13)	1/150	99.3%
Snake Pit 300 m (SP)	*21	21	21	21	21	21	0/105	100%
Brookside Drive 1700 m (BR)	**26	26	26	26	26	26	0/130	100%
Topanga Bridge 3600 m (TB)	30	30	30	30	30	30	0/150	100%
SIPP SITES								
Scratchy Trail 4800 m (ST)	23	23	22 (05/08/13)	22 (02/07/14)	23	23	2/115	98.3%
Owl Falls 6500 m (OF)	21	20 (02/07/14)	20 (05/08/13)	20 (02/07/14)	21	21	3/105	97.1%
Falls Drive (FD)	1	1	1	1	1	1	0/5	100%
Behind Abuelita's (BA)	3	3	3	3	3	2 (02/06/13)	1/15	93.3%

*SP dry during 9 sampling events: 11/20,13, 12/9/13, 12/19/13, 1/6/14, 1/29/14, 2/7/14, 2/20/14, 2/27/14, 3/24/14. (2/7/24 was first flush).

**BR dry during 4 sampling events: 9/18/13, 10/23/13, 7/15/14, 8/11/14.

Table 6-20 Summary of Sampling Site Completeness for Nutrient and Turbidity data, 12/19/12-08/11/14.

Site Name	Total Possible Sampling Dates	Total nitrate-N	Total nitrite-N	Total ammonia-N	Total orthophosphate	Total turbidity	Missing Data Points/ Total	% Complete
Topanga Lagoon (TL)	30	30	30	30	30	28 (12/19/12, 03/24/13)	2/150	98.7%
Snake Pit 300 m (SP)	*21	21	21	21	21	19 (12/19/12, 03/24/13)	2/105	98.1%
Brookside Drive 1700 m (BR)	**26	26	26	26	26	25 (12/19/12)	1/130	99.2%
Topanga Bridge 3600 m (TB)	30	30	30	30	30	29 (12/19/12	1/150	99.3%
SIPP SITES								
Scratchy Trail 4800 m (ST)	23	23	23	23	23	22 (12/19/12	1/115	99.1%
Owl Falls 6500 m (OF)	21	21	21	21	21	20 (12/19/12)	1/105	99.0%
Falls Drive (FD)	1	1	1	1	1	1	0/5	100%
Behind Abuelita's (BA)	3	3	3	3	3	3	0/15	100%

*SP dry during 9 sampling events: 11/20,13, 12/9/13, 12/19/13, 1/6/14, 1/29/14, 2/7/14, 2/20/14, 2/27/14, 3/24/14. (2/7/24 was first flush).
**BR dry during 4 sampling events: 9/18/13, 10/23/13, 7/15/14, 8/11/14

6.5 Discussion

Nitrate-N, nitrite-N, ammonia-N, and orthophosphate are all generally associated with anthropogenic inputs into aquatic systems and are directly related to amount of algal growth and potential eutrophication cycles. Observations during this study indicate that while levels of ammonia and orthophosphate are a concern associated with septic, graywater, transient and recreational impacts, overall nutrient loading continues to be low overall. This is consistent with previous study results for the lower reaches of the creek below town (Dagit et al. 2004).

The impact of recreational visitors and transient encampments, as well as potential inputs from illegal marijuana farms seems correlated to the spikes we see of ammonia and orthophosphate. The potential for a marijuana farm in this area is high. Transient activity and RV dumping appears to contribute greatly to the water quality issues in Topanga Creek. For several months during snorkel surveys and water quality monitoring events, a wet spot was observed in the pullout along Topanga Canyon Boulevard near Brookside Drive (1700 m). The wet spot was associated with a strong urine smell. Brookside Drive had the highest levels of ammonia followed by Snake Pit. Snake Pit is an area close to the PCH, which also gets a lot of transient activity, and so the high levels at this site could be due to that.

Overall, our initial hypothesis that nutrient levels decreased downstream from the town and upper watershed appears to be true for some nutrients but not all. Nitrate and orthophosphate are highest at the site closest to town (OF) and then drop, fairly dramatically at the next site, approximately 1700 m downstream (ST). Nitrite and ammonia are higher at ST than OF, although only slightly and levels of those two nutrients jumps around through the rest of the creek. The high levels of ammonia at Brookside Drive (BR) could be attributed to the RV dumping of urine waste along a nearby Topanga Canyon Blvd. pullout. Further monitoring and patrolling of this site along Topanga Canyon Blvd. could potentially solve the high ammonia levels at this site.

Algae cover, in general, was very low throughout the study period with two common species primarily found. This is another indication that eutrophication did not appear to be an issue during this study period. Rainfall was extremely low throughout the study period as well. It’s possible that with more rainfall, and more runoff from town, eutrophication and algae blooms could be a problem in Topanga Creek, and therefore, runoff from town and overall watershed management should not be ignored as a potential issue.

Standards for pollutants of concern have been established in the Basin Plan (LARWQCB 1994 with 2011 updates) and through the California Toxics Rule (CTR) (EPA 2000), with the goal of ultimately setting Total Maximum Daily Loads (TMDL’s) for each of these parameters in order to achieve compliance to all standards. The Basin Plan generally establishes a numeric and/or narrative objective for conventional pollutants and minerals, while the CTR has objectives for metals and organics. The 303(d) list identifies the parameters for which each watershed is impaired. Topanga Creek has been listed for lead in the upper watershed and bacteria at Topanga Beach. No other pollutants of concern have been listed for the watershed.

However, levels of nutrients, pathogens, sediments, trash and heavy metals are all potential problems in every watershed. The studies in Topanga Lagoon and creek have directed sampling to identify if any of these parameters are currently a concern and if so, to identify potential sources and trends of exceedance.

The Basin Plan also identifies the beneficial use of water quality objectives, which are summarized below for Topanga Lagoon and creek (Table 6-21). Although there have been some exceedances for FIB, the nutrient, water temperature and dissolved oxygen levels are all within the water quality objective ranges.

Table 6-21 Beneficial uses and pollutants of concern for Topanga Lagoon and creek, Los Angeles Regional Water Quality Control 1994.

Parameter	Beneficial Use Water Quality Objective or Definition	Topanga Lagoon Results	Topanga Creek Results
Navigation		NA	NA
REC 1 (Water contact recreation)	Fecal coliform shall not exceed a single sample limit of 400 MPN/ 100 mL	Exceedances	Exceedances
REC 2 (Non-water contact recreation)	Fecal coliform shall not exceed a single sample limit of 400 MPN/ 100 mL	Exceedances	Exceedances
Warm Water	Remain < 80^0F, raise no more than 5^0F above normal	No exceedances	No exceedances
Cold Water	Not be altered more than 5^0F above normal	No exceedances	No exceedances
Estuary	Uses of water that support, preserve or enhance estuarine habitats	Limited function	NA
Rare	Uses that support habitats necessary for state or federally listed species	Supports endangered Tidewater gobies	Supports several state and federally listed aquatic species
Migratory	Uses supporting anadromous fish	Limited function	Limited function, Passage opportunities limited
Spawning	Uses supporting high quality habitat for reproduction and early development of fish	Passage opportunities limited	Functional areas limited in lower reach of creek
Wetlands	Uses that support preservation, enhancement of wetland habitats	Limited function	NA

When we compare the levels of nitrates, nitrites, orthophosphates and ammonia observed in Topanga Creek with those found in other creeks within the Santa Monica Mountains, including both Malibu Creek, and reference sites such as Arroyo Sequit, Solstice and Cold Creeks, it appears that Topanga remains in fairly good shape. The levels of nutrients measured in Topanga Creek are significantly lower than those found at the mouth of Malibu Creek (Table 6-22).

Table 6-22 Comparison of Water Quality Parameters from Creeks in the North Santa Monica Bay December 2012- July 2013.

Site	Average Water Temp	Average Dissolved Oxygen	Average pH	Average nitrate-N	Average nitrite -N	Average ammonia-N	Average ortho-phosphates
WQ Target Guideline	**<26^{o}C**	**>5 mg/l**	**6.5-9**	**<1 ppm**	**<1 ppm**	**0.4 ppm (pH adjusted)**	**<0.10 ppm**
Topanga Lagoon (n=13)	16	8.7 (90%)	7.7	0.03	0.02	0.06	0.07
Topanga Bridge (n=13)	12	8.5 (79%)	7.9	0.01	0.02	0.22	0.06
Arroyo Sequit * (HTB-19) (n= 9)	14	8.05	7.7	0.01		0.16	0.15
Solstice Creek* (HTB-14) (n= 9)	15	8.55	7.7	0.07		0.06	0.12
Cold Creek* (HTB-3) (n= 9)	13	8.79	7.8	0.05		0.25	0.12
Malibu Creek* (HTB-1) (n=9)	16	9.38	7.9	1.03		0.09	1.83

Numbers highlighted in yellow indicate exceedance of water quality target. First flush rain events excluded.
*Data courtesy of Heal the Bay Stream Team

6.6 Summary

- Nutrient and algae levels were, in general, low throughout the study period, with only occasional exceedances. Orthophosphates were frequently in exceedance at Owl Falls and Scratchy Trail.
- In-situ parameters (water temperature, dissolved oxygen, pH, conductivity, salinity) were, in general, within the standard ranges for wildlife.
- Rainfall was below normal for both years the study took place, and significant rain events were few and far between. Therefore, flow was consistently low throughout the study period as well.
- On average, nitrate and orthophosphate levels decrease from Owl Falls (OF, 6500 m; the site closest to town) downstream, especially between OF and ST (4800 m)
- On average, Brookside Drive (BR, 1700 m) had the highest levels of ammonia

- Further patrolling of the state park for transient and RV dumping activity could help with any exceedances in the creek, similar to the fact that further enforcement of the no-dogs-allowed-on-beach rule could probably help with the FIB issues at the beach/lagoon.

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7 Physical Habitat Assessment Results

7.1 Introduction

Physical habitat data was collected as part of the Surface Water Ambient Monitoring Program (SWAMP) Bioassessment Procedures (Ode 2007) to quantify physical and chemical characteristics of stream habitat associated with concurrent benthic macroinvertebrate, diatom and soft-body algae collection (Herbst and Silldorff 2006, Ode et al. 2005). The protocol allows for repeatable data collection measures in order to obtain quantitative data on a stream's physical/habitat condition and benthic invertebrate assemblages. It also allows for comparison of stream conditions throughout the state of California.

For the purpose of this report, we have presented the physical habitat data as a separate section, although the information is relevant to the analysis and discussion of the benthic macroinvertebrates (Chapter 9), diatoms and soft-body algae (Chapter 11), and most importantly, to the examination of the trophic level interactions associated with the trophic level analysis of Topanga (Chapter 12).

7.2 Methods

Data Collection

Physical habitat data was collected in Topanga Creek on 30 April 2013 (Upper Topanga: 4500-4650m; 34º04.314 118º35.213) and 2 May 2013 (Lower Topanga: 3200-3350m; 34º03.685 118º35.123) as part of the SWAMP Bioassessment protocol. Data was also collected in Upper Topanga on 6 May 2014 and in Lower Topanga on 5 May 2014. This data was collected for each of the 150 meter reaches where sampling for benthic macro-invertebrates, diatoms, soft-body algae, and chlorophyll a were also collected. The presence, life-stage and abundance of all amphibians, reptiles, and fish were noted throughout a 500 meter reach (3200-3700m and 4500-5000m) which has been surveyed since 2000.

For each location, 21 main transects were placed systematically along a 150 meter reach of the creek. Eleven transects were placed 15 meters apart perpendicular to the direction of flow. Ten additional inter-transects were placed equidistant between each of the main transects. Prior to collecting transect data, ambient water chemistry measurements (pH, dissolved oxygen (mg/L and % sat), specific conductivity (µS/cm), water temperature (ºC), air temperature (ºC), and salinity (ppt) were taken. Alkalinity and hardness were measured using test strips in 2013. In addition, water samples were collected for later analysis of turbidity (NTU) with the LaMotte Turbidimeter 2020, nutrients were tested using the LaMotte Smart3 Colorimeter, and fecal indicator bacteria were processed according to standard protocol. Flow (cfs) was measured using a Marsh-McBirney Flowmate 3000.

After benthic macroinvertebrates, diatoms and soft-body algae were collected at each of the 11 main transects using the reachwide benthos (RWB) procedure, the following habitat data was collected for each transect: wetted width (m), depth (cm), bankfull width (m), bankfull height (cm), canopy cover (measured using a convex spherical densiometer), and transect substrate measurements (below). Visual estimates were used to collect data on riparian vegetation, human influence, instream habitat complexity, and bank stability.

The transect substrate measurements quantify particle size frequency distribution, which provides valuable data on stream habitat conditions that can affect benthic macroinvertebrate distribution. As part of this, the Wolman pebble count technique (Wolman 1954) was employed. If the particle was cobble-sized, the percent embeddedness was recorded. Additional cobble particles were used to estimate the percent embeddedness if too few cobbles were found along transects. The presence of course particulate organic matter (CPOM), algae and macrophytes was also recorded as part of the transect substrate data.

For each of the ten inter-transects, wetted width, depth, transect substrate measurements, and visual estimates of in-stream channel type were also collected. Inter-transect gradient was not directly measured, but inferred for the whole reach based on previously collected gradient data.

Data Analysis

Data was entered into Microsoft Excel for further analysis. Summary tables were generated to show the results for physical habitat characteristics, water quality, canopy cover and substrate composition.

For instream habitat complexity, the cover values (from 1 to 5) for nine different channel features along each transect were tabulated for each reach. To get an indication of how much each feature contributed to overall instream complexity for each reach, the frequency of occurrence was calculated as the number of transects with at least sparse cover (>1)/total possible (n = 11 transects). The resulting frequencies for both reaches were represented graphically.

To characterize the riparian vegetation along the length of each reach, the proportion of each of four cover values (0=absent, 1=sparse, 2=moderate, 3=heavy, 4=very heavy) were graphed for the lower and upper reach for 2013 and 2014. The cover values for each riparian vegetation type at the left and right bank for each of the 11 transects were used to calculate the proportion values.

7.3 Results

7.3.1 *Physical Habitat Characteristics and Water Chemistry*

As shown in Table 7-1 in 2013 the average wetted width and average depth for the upper reach (4.4 m and 12.6 cm) were slightly greater than that of the lower reach (4.2 m and 12.0 cm). In 2014 the average wetted width remained about the same as the previous year for the upper reach (4.5 m), although the average depth was slightly less (10.9 cm) than in 2013. The lower reach had a lower average wetted width (4.0 m) and average depth (9.9 cm) than the previous year.

Stream discharge was generally low, although the value in the lower reach in 2013 (0.006 m^3/s) was double that of the same reach in 2014 (0.003 m^3/s). The upper reach discharge was 0.004 m^3/s in 2013, and a discharge value was not recorded in 2014 because flows were so low. In 2013 bank stability was greatest in the upper reach (91%) but the lower reach was also high (82%). Bank stability was slightly higher in 2014 for the upper reach (100%) but remained the same in the lower reach (82%).

In 2013 the majority of the lower reach consisted of riffles and runs (25 and 75%, respectively) while the upper reach was more complex with 5 flow habitats (cascade/fall, riffle, run, glide and pool). In 2014 a majority of the lower reach consisted of riffles (30%) and glides (70%) while the upper reach continued to have a mix of flow habitats. None of the flow habitats were dry during either year.

In 2013, water temperature, pH, and specific conductivity were all greater for the upper watershed than the lower, but consistent with previous data collected in the spring (2000-2012 *RCDSMM unpublished data*).

Table 7-1 Summary of Physical Habitat Conditions Topanga Creek Spring 2013 and 2014.

Location	**TC3200-3350m 2013**	**TC4500-4650m 2013**	**TC3200-3350m 2014**	**TC4500-4650m 2014**
Water Quality Measures				
Water Temperature (^{o}C)	14.7	16	14.9	14.7
Air Temperature (^{o}C)	15.9	17	18	14.2
Dissolved Oxygen (mg/l)	9.26	7.65	7.65	7.34
pH	6.36	6.7	8.27	8.29
Specific conductance (µS/cm)	1375	1441	1423	NR
Salinity (ppt)	0	1.5	1	0
Alkalinity (mg/l) (Test strip)	300	300	NR	NR
Turbidity (NTU)	NR	0.4	0.38	4.26
Nitrate – N (ppm)	0	0	NR	NR
Nitrite – N (ppm)	0	0.01	NR	NR
Ammonia N (ppm)	0	0.18	NR	NR
Orthophosphate (ppm)	0.16	0.17	NR	NR
Time Sampled	0910	0930	0900	0930
Physical Habitat Characteristics				
Reach Length (m)	150	150	150	150
Average wetted width (m)	4.2	4.4	4.0	4.5
Average depth (cm)	12	12.6	9.9	10.9
Average velocity (ft/s)	NR	NR	NR	NR
Discharge (m^3/s)	0.006	0.004	0.003	NR
Slope (%)	<3	>3	<3	>3
Elevation (m)	200	400	200	400
Vegetative Canopy Cover (%)	82	65	95	83
*Microalgae Thickness (mm)	0	0	0	0
**Macroalgae Presence (%)	24	10	5	4
Macrophyte Presence (%)	18	26	28	18
Bank Stability (%): Stable	82	91	82	100
Vulnerable	9	0	18	0
Eroded	0	0	0	0
NR	9	9	0	0
Flow Habitats (%): Cascade/Fall	0	6.5	0	0
Rapid	0	0	0	0
Riffle	25	19	30	31.5
Run	75	4.5	0	0
Glide	0	10	70	28.5
Pool	0	60	0	40
Dry	0	0	0	0
Average Embeddedness (%)	49	26	49	44
Substrate Size (%): Bedrock	0	9	0	6
Boulder	24	33	26	33
Cobble	14	26	7	14
Gravel	29	13	26	23
Sand	28	18	42	26
Fines	10	6	4	3
Hardpan	0	0	0	0
Concrete/Asphalt	0	0	0	0
Wood	0	0	0	0
Other	0	0	0	0

NR= Not recorded; *Microalgae thickness code was 0 for all reaches and years, which corresponds to (absent=<1mm) ; **% Presence includes unattached and attached macroalgae.

In 2014 water temperature was greater in the lower watershed, while pH was about the same in the lower and upper watershed. However, dissolved oxygen (mg/L) was slightly higher in the lower watershed than the upper in both 2013 and 2014.

7.3.2 Streambed Substrates, Embededness and Canopy Cover

The average embeddedness was greater (49%) in the lower reach than the upper (26%) in 2013. By contrast the embeddedness in the lower reach (49%) was similar to the upper (44%) in 2014. In 2013 and 2014 both reaches were composed of a fairly even distribution of fines, gravel, cobble, and boulders. The lower reach, which has a lower gradient (<3%), did not have any bedrock. Smaller substrates (< 2”) such as fines and gravel were more frequent in the lower reach, whereas larger substrate (> 2”) such as cobbles, boulder, and bedrock were more frequent in the upper reach, which has a higher gradient (> 3%).

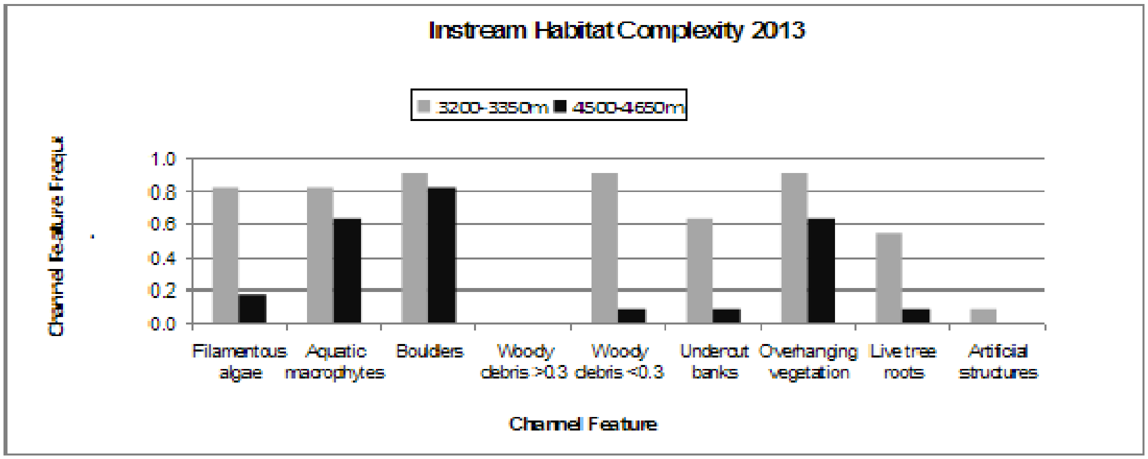
The data summarized in Table 7-1 indicates that although the channel width, depth and flow were relatively consistent between the two reaches, gradient plays a role in the flow habitats present. The upper gradient reach (4500-4650m) was pool dominated, and the lower gradient reach (3200-3350m),was dominated by run-riffle complexes. This pattern is also consistent with the higher percent of fines and gravel in the lower gradient reach and more cobble-boulder substrate in the upper gradient reach.

Vegetative canopy cover was generally high, with 82% cover observed in the lower reach in 2013 and 95% in 2014. Similarly, an increase in percent canopy cover was observed in the upper reach from 2013 (65%) to 2014 (83%).

In 2013, the macroalgae presence was higher in the lower reach (24%) than the upper reach (10%). However, in 2014 the macroalgae presence in the lower (5%) and the upper (4%) were almost equal.

7.3.3 Instream Habitat Complexity and Riparian Vegetation

Instream habitat complexity includes abundance levels of filamentous algae, aquatic macrophytes, boulders, woody debris, undercut banks, overhanging vegetation, living tree roots and artificial structures. Scores for physical/habitat conditions were not generated. However, instream habitat complexity for each reach was evaluated, and the frequency of channel features recorded along each reach that had a cover value greater than (1) is shown (Figure 7-1)



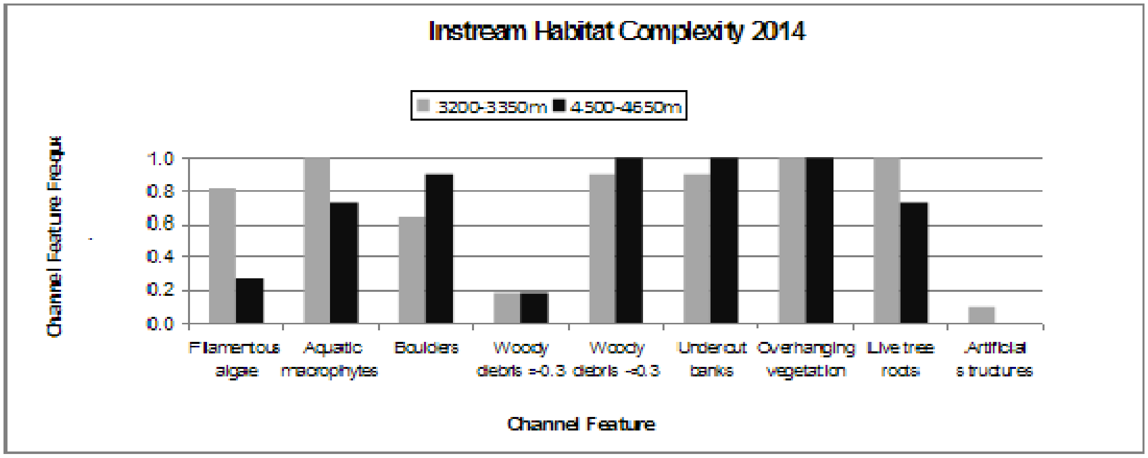


Figure 7-1 Instream habitat complexity of two reaches in the Topanga Creek watershed (3200-3350m and 4500-4650m) for 2013 and 2014. The frequency of each feature represents the number of times each feature was present (cover value ≥ 1) over the 11 transects of each reach.

In 2013, the lower reach (3200-3350 m) had greater instream habitat complexity, with each channel feature occurring more frequently than the upper reach. Neither of the reaches had large woody debris (> 0.3 m), and only the lower reach had artificial structures, due to proximity of Topanga Canyon Boulevard. Aquatic macrophytes, boulders, and overhanging vegetation were frequent for both reaches.

In 2014, both the lower reach (3200 -3350 m) and upper reach (4500-4650 m) had greater habitat complexities than in 2013. Each reach exhibited an increase in the frequency of almost every channel feature present in 2013. In addition, large woody debris (> 0.3 m) was observed in 2014, compared to none observed the previous year. Aquatic macrophytes, boulders, woody debris (<0.3 m), undercut banks, overhanging vegetation and live tree roots were frequent for both reaches.

Finally, the different classes of riparian vegetation contributing to each reach are shown in Figures 7-2 and 7-3. Figure 7-2 shows the proportion of riparian vegetation cover values for the lower reach (3200-3350m) and upper reach (4500-4650 m) in 2013. Figure 7-3 shows the same values for each reach in 2014.

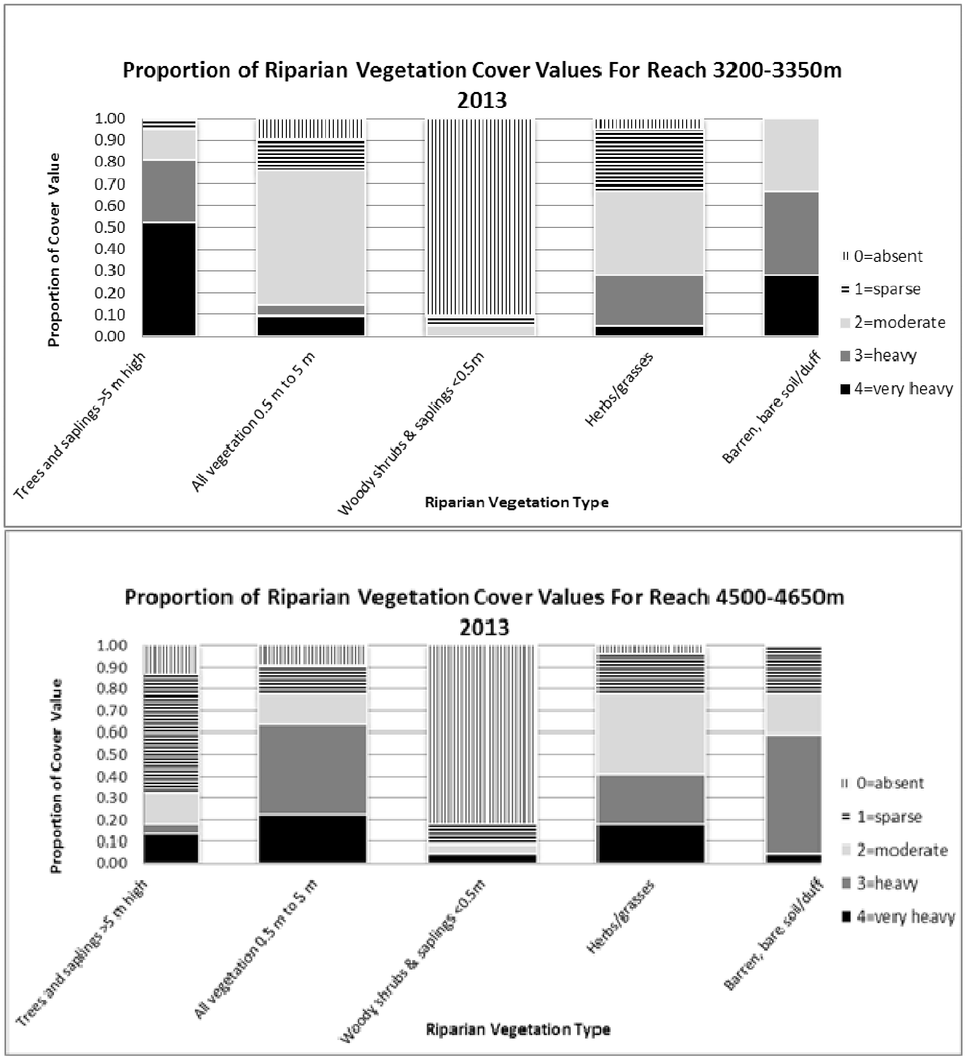


Figure 7-2 Proportions of riparian vegetation cover values of two reaches in the Topanga Creek watershed (3200-3350m and 4500-4650m) for 2013 where areal cover (shading) for each of the vegetation types is represented as 0) absent, 1) sparse (<10%), 2) moderate (10-40%), 3) heavy (40-75%), or 4) very heavy (>75%).

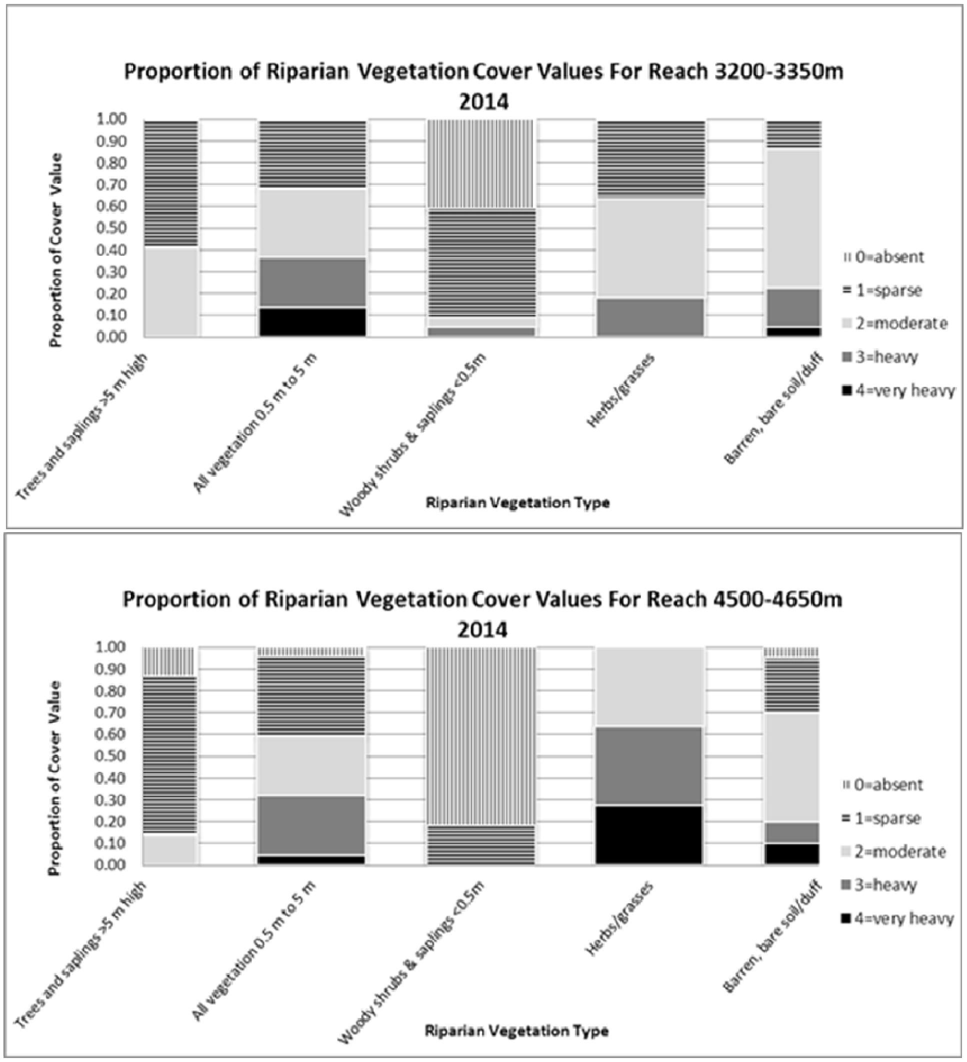


Figure 7-3 Proportions of riparian vegetation cover values of two reaches in the Topanga Creek watershed (3200-3350m and 4500-4650m) for 2014 where areal cover (shading) for each of the vegetation types is represented as 0) absent, 1) sparse (<10%), 2) moderate (10-40%), 3) heavy (40-75%), or 4) very heavy (>75%).

For both reaches, herbs and grasses had a fairly even distribution of sparse (1), moderate (2) and heavy (3) cover values in 2013 and 2014. In 2013 trees and saplings > 5m had the highest proportion of very heavy cover in the lower reach. However, the upper reach had a sparse cover of this vegetation type. Barren/bare soil/duff was a combination of moderate, heavy and very heavy cover for the lower reach, and mostly heavy in the upper reach. All vegetation from 0.5m to 5m was mostly moderate in the lower reach but heavy to very heavy in the upper reach.

In 2014 trees and saplings > 5m had the highest proportion of sparse cover in the lower and upper reaches, in contrast to 2013. Barren/bare soil/duff was mostly moderate for both the lower and upper reaches. All vegetation from 0.5 to 5m had a fairly even distribution of sparse, moderate and heavy cover for both the lower and upper reaches.

Riparian vegetation is an important element of stream habitat. In Topanga Creek, the extent of riparian vegetation is limited both by proximity of steep canyon walls in the narrow section of the upper gradient reach (4500-4650 m), as well as the frequency of flood events. There has been substantial growth of riparian vegetation throughout the creek since the last flood events that occurred in 2005, 2010 and 2011.

7.4 Discussion

The past three years have been very dry, and the physical habitat conditions reflect that. We have not had a flushing pulse of flow since March 2011. The one major storm in February – March 2014 was short lived and insufficient to scour the channel. Systematic sampling of physical habitat data is essential to collecting representative and quantifiable data, especially for the highly variable elements that comprise stream habitat structure. Prior to 2013, the physical habitat characteristics were documented using the methods of the CA Rapid Bioassessment Protocol (CDFG 1999) and that data remains to be examined in comparison to the information gathered using the new SWAMP protocols (Ode 2007, Fetscher et al. 2009).

Physical habitat includes documenting the flow and sediment regimes, channel and flood-plain structure, hydrologic alterations, riparian vegetation quality and extent, and responses to anthropogenic stressors. All of these variables affect the abundance, diversity, and seasonal community structure of primary producers such as diatoms, soft-bodied algae, macroalgae, and benthic macroinvertebrates. They can ultimately dictate changes in a variety of trophic levels when the physical elements of habitat respond to changes in the environment. As such, physical habitat documentation is critical to understanding the relative importance of various environmental indicators.

Overall, both reaches of Topanga Creek have relatively stable banks and a variety of in-stream habitat types (runs, riffles, pools) that can support a complex assemblage of aquatic organisms. The higher level of fines and gravel in the lower reach are highly mobile. Snorkel survey and habitat typing focused on habitat for endangered steelhead trout documented the pulses of sediment moving downstream with storm events over time (Dagit and Krug 2011). While the specific location of the sediment slugs varies over time and results in decreased pool habitat in certain reaches, the overall amount of pool habitat and refugia for fish remained fairly constant, despite a very wet year in 2005.

Overall, channel morphology has also remained fairly constant over time (Dagit and Krug 2011).

7.5 Summary

- Rainfall was below normal for both years the study took place, and significant rain events were few and far between. Therefore, flow was consistently low throughout the study period as well.
- The average wetted width of the creek remained fairly constant throughout the study but average depths decreased in some locations in 2014.
- Water temperature, pH, and specific conductivity were relatively stable and consistent with previous data collected (Dagit et al 2004, 2000-2012 RCDSMM *unpublished data*).
- Habitat types remained consistent during the course of the study with riffles, runs and glides dominate in the lower reach of the creek (below 3600 m) and a more complex mix of flow habitats (cascade/fall, riffle, run, glide and pool) found upstream. None of the flow habitats were dry during either year.
- Geomorphology and gradient affect the types of flow habitats present, with the lower gradient reach below 3600 m (<3%) being dominated by run-riffle complexes and the upper gradient (3-6%) being pool dominated.
- Smaller substrates such as fines and gravel were more frequent in the lower reach, whereas larger substrate such as cobbles, boulder, and bedrock were more frequent in the upper reach, which has a higher gradient (> 3%).
- Instream habitat complexity includes abundance levels of filamentous algae, aquatic macrophytes, boulders, woody debris, undercut banks, overhanging vegetation, living tree roots and artificial structures. In 2014, both the lower and upper reaches had greater habitat complexities than in 2013 despite the low flows.
- The proportion of cover values for several riparian vegetation types were estimated for the lower and upper reaches. Trees and saplings > 5m had the highest proportion of sparse cover in both the lower and upper reaches.

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8 Spatial, Temporal, and Regional Analyses of Benthic Macroinvertebrate Communities in Topanga Creek: 2002-2014

8.1 Abstract

Benthic macroinvertebrate bioassessment was conducted in Topanga Creek as part of a larger bacterial source-identification study. The Southern California Coastal Index of Biotic Integrity (SCC-IBI) was applied to samples collected 2003-2014 to analyze spatial and temporal correlations between biotic integrity and water quality conditions. A few distinct trends regarding the benthic macroinvertebrate (BMI) community of Topanga Creek emerged during the course of this study. 1. SCC-IBI scores for Topanga Creek range from 'Very Poor' to 'Fair' 2. SCC-IBI scores indicate a significant negative correlation between % non-insect taxa and levels of dissolved oxygen. 3. Taxa composition is more similar across samples collected on the same date, versus samples collected at any one site. 4. Functional feeding group composition is more stable than taxa composition per site and over time. 5. Worsening drought conditions through winter 2012/2013 may have caused a significant shift in species composition in Topanga Creek. 6. Regional comparison of Topanga Creek indicates relatively degraded conditions. 7. Such conditions may be a result of human and natural influences, particularly land development and drought.

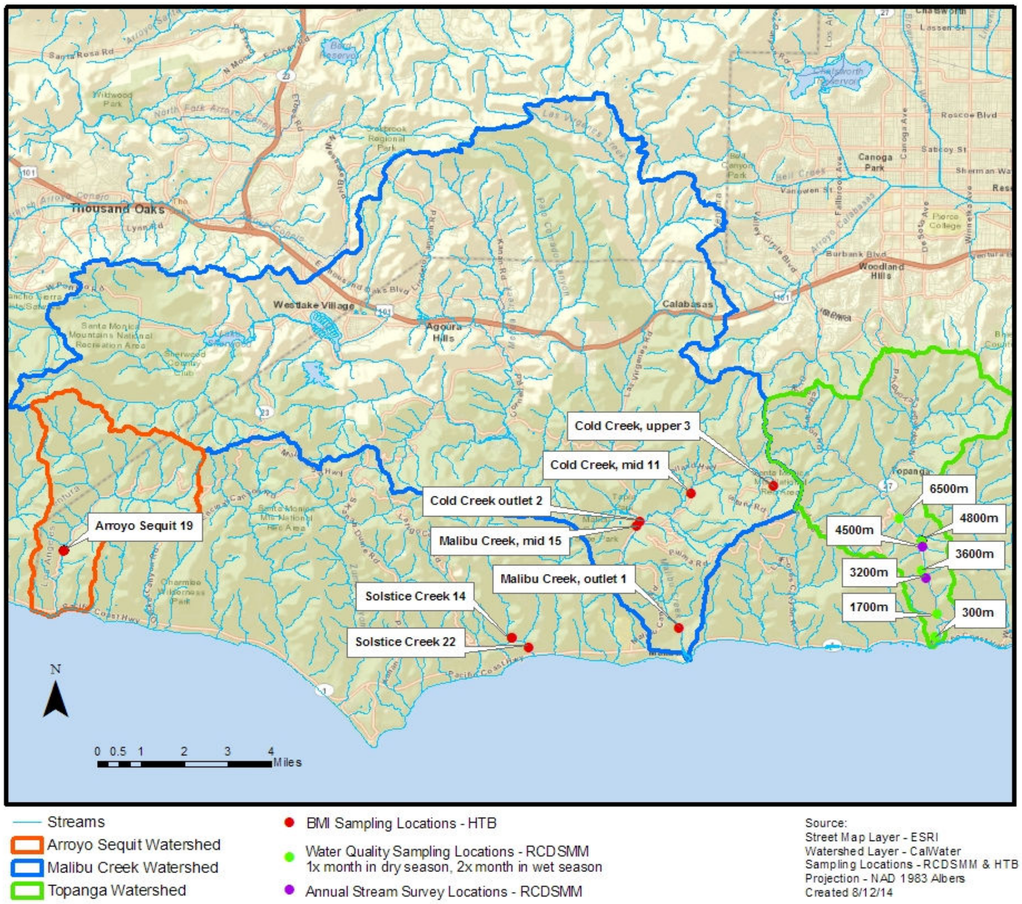
8.2 Introduction

The benthic macroinvertebrate (BMI) community, such as snails, dragonfly nymphs, true fly larvae, worms, and other bottom-dwelling aquatic organisms of a freshwater stream, are vital indicators of riparian ecosystem health (Ode et al. 2005). Benthic macroinvertebrate sampling adds a biotic element to standard water quality testing procedures and is an invaluable tool for ecologists, resource management professionals, and anyone interested in investigating and maintaining healthy streams. As primary consumers of allochthonous (terrestrial leaf litter) and autochthonous (aquatic plant) detritus, benthic macroinvertebrates are the most basic link between both aquatic and riparian vegetation and the rest of the stream community (Voshell 2002). Filling distinct feeding niches, some species shred whole leaves and stalks, others scrape up the film left behind, ultimately releasing a large pool of nutrients that can be absorbed by higher trophic levels (Covich et al. 1999). Analysis of functional feeding group (FFG) diversity can shed light on how nutrients begin to flow at these primary trophic levels.

In addition to FFG designations, many families, genera, or species have assigned tolerance values 0-10 (CAMLnet. 2003) that describe the organism's ability to live in polluted waters. Another key feature of benthic macroinvertebrates is their tendency to reveal current and past ecological disturbance (Boulton 1992). Some taxa, such as mosquitoes, may appear and disappear within a week, while others, like some common dragonflies, develop underwater over the course of a year or more (Voshell 2002). Therefore, shifts in species composition may be the result of a current disturbance event or one that occurred within the year. Habitat preferences, limitations, and additional life-history traits have been described for 3,857 North American lotic macroinvertebrate species (Vieira et al. 2006). Indexes of Biotic Integrity (IBI) have been developed using this information to evaluate BMI community composition and distribution and to assign numeric and descriptive scores of ecological health (Fetscher et al. 2009, Ode 2007).

The Southern California Coastal Index of Biotic Integrity (SCC-IBI, Ode et al. 2005) allows for a regionally-focused quantification of the ecological condition of a sampling site as characterized by its benthic macroinvertebrate community. SCC-IBI scores are calculated as a sum of the following seven metrics: EPT taxa (Ephemeroptera, Plecoptera, Trichoptera), Coleoptera taxa, predator taxa, percent non-insect taxa, tolerant taxa, intolerant individuals, and percent collector-gatherer individuals. In this paper, the SCC-IBI is applied to three distinct BMI collections in order to gain spatial (water quality samples at five Topanga Creek sites 2013-2014), temporal (annual stream survey samples from two sites 2002-2014), and regional (Heal the Bay data from Arroyo Sequit, Cold Creek, Malibu Creek, Solstice Creek 2000-2013) perspectives on the biotic integrity of Topanga Creek (Figure 8-1).

Topanga Creek, a small southern California coastal drainage, lies within an approximately 47-km^2 watershed that drains into the Santa Monica Bay, in Los Angeles County. The watershed provides vital habitat for endangered steelhead trout, 22 species of amphibians and amphibians, nine species of bats, and numerous other plants and animals. Approximately 70% is protected parkland owned by California Department of Parks and Recreation. The remaining 30% is developed within the village of Topanga, (population 12,000 as of 2010, Los Angeles County Census 2010). Development along Topanga Creek begins at about 6500 m (upstream from the ocean) and continues upwards. The mouth of the creek lies within Topanga Beach which received poor grades for bacterial levels on Heal the Bay’s Beach Report Card between 2006 and 2014.



Source:
Street Map Layer - ESRI
Watershed Layer - CalWater
Sampling Locations - RCDSMM & HTB
Projection - NAD 1983 Albers
Created 8/12/14

Figure 8-1 Topanga Creek and Santa Monica Mountain sampling sites 2000-2014.

In 2012, a source identification study was launched in collaboration with Los Angeles County, the Resource Conservation District of the Santa Monica Mountains (RCDSMM), and the Jay Lab University of California at Los Angeles (UCLA) to investigate potential sources of bacteria observed at Topanga Beach. Water quality testing occurred at eight sites between the ocean outlet and 6500 m upstream from to December 2012 to August 2014, documenting habitat condition observations and water sample sampling for nutrients and fecal indicator bacteria (FIB) analysis. Benthic macroinvertebrates were collected from six of these sites on four occasions in 2013-2014.

Comparing water quality conditions to the community composition and distribution of BMI provides an opportunity to identify correlations between the biotic integrity of Topanga Creek with instances of nutrient pollution, low flows, low dissolved oxygen, and more. Additional BMI and water quality sampling during annual stream surveys in spring (Apr/May) 2003-2014 at two reaches were also incorporated into this study to provide a longer-term context of how creek conditions or climate may affect BMI community diversity over time. These results were compared to other sampling locations within the Santa Monica Bay allowing comparison of regional SCC-IBI scores and to place Topanga Creek within that regional context. The application of SCC-IBI, alongside additional analyses such as Simpson's Diversity Index and Bray-Curtis Dissimilarity measure, provide a comprehensive evaluation of the health of the Topanga Creek watershed and the relationship between various stressors and its biological condition.

8.3 Methods

Sample Collection

BMI collections occurred in conjunction with water quality testing in May and September 2013, as well as April and July 2014 along a continuum (6500 m to 300 m) of five sites (Owl Falls- OF, Scratchy Trail - ST, Topanga Bridge -TB, Brookside - BR, and Snake Pit- SP) according to California Rapid Bioassessment Procedure (Ode 2007) (Table 8-1). Starting at the downstream end of the site, a riffle within the reach was randomly selected and a total of nine 1-ft. wide kick net samples were collected at each left, center, and right of three consecutive riffles, and combined for a composite sample of nine kicks. SP was only sampled in 2014, and BR was not sampled in September 2013, as the site was dry.

For the annual stream surveys in Topanga Creek, the California Rapid Bioassessment Procedure (Ode 2007) was used from 2003-2014, but in 2013 and 2014 the SWAMP Bioassessment Procedure (Fetscher et al. 2009) was used. A 1ft^2 kick net sample was collected every 15 m along a 150 m transect, alternating along the way between 25%, 50% and 75% from right bank, for a composite sample of 11 kicks.

Annual stream survey collections took place in spring (April or May) of 2003, 2004, 2005, 2006, 2009, 2010, 2011, 2012, 2013, and 2014 at two locations: Upper Topanga (UT) and Lower Topanga (LT)(Table 8-1). Upper Topanga is above the Topanga Canyon Bridge (MM2.02) in the main stem of the higher gradient (3-6%) reach (4500 m). Lower Topanga Creek is in the main stem of the creek in the low gradient (<3%) reach (3200 m). Samples collected from UT 2004 and 2007, and LT and UT in 2008 and 2009 were not viable for processing and are not included in analysis.

Table 8-1 Topanga Creek Benthic Macroinvertebrate Sampling Sites 2003-2014.
Samples highlighted in gray had at least 500 individuals for SCC-IBI analysis.

ANNUAL STREAM SURVEY COLLECTIONS 2003-2014			WATER QUALITY COLLECTIONS 2013-2014		
SITE	DATE	*n*	SITE	DATE	*n*
Lower Topanga (3200m)	5/13/2003	104	Snake Pit (300m)	4/24/2014	492
	5/3/2004	464		6/19/2014	354
	5/27/2005	3516	Brookside (1700m)	5/8/2013	322
	5/8/2006	398		7/1/2013	6
	5/1/2007	2654		4/24/2014	689
	4/26/2010	296		6/19/2014	136
	4/28/2011	255	Topanga Bridge (3600m)	5/8/2013	61
	4/23/2012	208		7/1/2013	10
	5/2/2013	371		9/18/2013	227
	5/5/2014	1156		4/24/2014	341
Upper Topanga (4500m)	5/14/2003	744		6/19/2014	1311
	5/4/2004	DRY	Scratchy Trail (4800m)	5/8/2013	178
	5/17/2005	1101		7/1/2013	13
	5/9/2006	601		9/18/2013	71
	5/2/2007	DRY		4/24/2014	788
	4/22/2010	560		6/19/2014	589
	4/29/2011	178	Owl Falls (6500m)	5/8/2013	47
	4/24/2012	117		7/1/2013	6
	4/30/2013	308		9/18/2013	837
	5/6/2014	502		4/24/2014	1933
				6/19/2014	4757

Annual stream survey samples were also collected from nearby creeks, such as Arroyo Sequit, Cold Creek, Solstice, and Malibu from 2000-2013 by the Heal the Bay (HTB) Stream Team and processed by Sustainable Land Stewards International (SLSI) (Table 8-5). From 2000-2012 annual stream surveys were done according to the California Rapid Bioassessment Method (2005, 2009). Standard 1-ft. wide kick nets were deployed and collected at each left, center, and right of three consecutive riffles, and combined for a composite sample of 9 kicks. Thereafter (2013-2014), SWAMP protocol was followed. All samples were preserved either in 90% ethanol or by freezing and were archived at the RCDSMM until processing began.

Sample Processing and Analysis

Processing of archived BMI samples began in June 2013. Each sample was strained and, in most cases, samples were processed entirely. Using a dissecting microscope, organisms were sorted and identified to the lowest practical taxon- family, sub-family or species level when possible. Identifications were confirmed using the California Aquatic Bioassessment Laboratory (ABL) and Merritt et al. (2008). Processors also referred to Heal the Bay's benthic macroinvertebrate data from other nearby creeks within the Santa

Monica Bay 2000-2013. A second processor and/or supervisor checked a subsample of each sample to ensure completeness, and accuracy of identification. When identification was not possible, photographs were sent to Dan Pickard at CDFW ABL or identified to the lowest taxonomic level possible and recorded as non-distinct within that taxon. Data was recorded on a standardized processing sheet and transferred into an Excel database. Processing was evaluated for overall error by randomly selecting a subset of 10% of all samples having more than 500 individuals by assigning a random number to each sample. Ten percent of those samples' vials were then re-identified by another processor, and identification outcomes were compared. This resulted in an overall error of <10% to be applied to BMI data reporting.

Processed samples were assessed according to the Southern California Coastal Index of Biotic Integrity (Ode et al. 2005). For this index, seven metrics are used to assess ecosystem health: EPT taxa, Coleoptera, and predator taxa richness, % non-insect taxa, % tolerant taxa (TV>7), % intolerant individuals (TV<3), and % collector-gatherer + collector-filterer (CG+CF) individuals. Information regarding tolerance values and functional feeding groups was obtained on CAMLnet (2003). These seven metrics were scored according to Ode et al. (2005) in order to provide a single measure of overall ecosystem health (Table 8-2). As this metric was designed for samples of 500 individuals, samples with less than 500 organisms were not used for IBI calculations. For samples with more than 500 organisms, each individual was assigned a number and 500 random numbers were generated in order to create a subsample of 500 random individuals for IBI calculations.

Table 8-2 SCC-IBI metric scoring as adapted from Ode et al. 2005.

Total IBI score	Score of biotic integrity
0-13	Very Poor
14-26	Poor
27-40	Fair
41-55	Good
56-70	Very Good

Simpson's Index of Diversity was applied to measure species richness and evenness, which defines high diversity as having several different species of similar abundance, or 'evenness' (Simpson 1949). Simpson's Index (D) was calculated according to the following equation, where "n" is equal to the number of individuals of a particular species and "N" is equal to the total number of organisms found:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right)$$

Subtracting from one provides a reciprocal index ranging from 0 to 1, where 1 represents high diversity and vice versa. The sum can be interpreted as the probability that two individuals randomly selected from a sample will belong to different taxon.

Bray-Curtis analysis (Bray and Curtis 1957) is a measure of dissimilarity between two samples. It accounts for both ‘size’ and ‘shape’, so dissimilarity is a measure of both total number and species composition. When the coefficient is subtracted from 1, a measure of similarity is acquired. The Bray-Curtis coefficient was calculated as follows:

$$B - C = \frac{\sum_{i=1}^{n} |y_{i1} - y_{i2}|}{\sum_{i=1}^{n} (y_{i1} + y_{i2})}$$

Simpson’s Diversity Index and Bray-Curtis calculations were applied to whole samples, not sub-samples of 500, as they account for both sample size and shape. For water quality samples, this analysis was based on the species distribution between six primary taxa groups: *Baetis sp*., *Simulium sp., Chironomid sp.,* Ostracod, Amphipod, and other. For annual stream surveys, analysis was also based on species distribution to six different primary taxa groups: Chironomid, Crustacea, other-insecta, Gastropoda, EPT, and other. These groups were delineated to take into account dominant taxa in the different samples and the need for whole-sample inclusivity. At no point were water quality samples 2013-2014 compared to annual stream surveys 2003-2014.

Statistical analyses, including regression and t-tests were applied to compare results spatially and temporally within sampling types, and test for correlations between biotic indices and water quality conditions including average fecal indicator bacteria levels, nutrient levels (nitrite-N, nitrate-N, ammonia-N, orthophosphates), rainfall (inches), temperature (ºC), and dissolved oxygen (% sat.) to examine any possible relationships between those conditions and the BMI community assemblage.

8.4 Results

The results are organized by analyses type (1. SCC-Index of Biotic Integrity, 2. Taxa Composition and Diversity Measurements), as well as by sampling type (1. water quality samples 2013-2014, 2. annual stream surveys 2003-2014, 3. regional stream surveys 2000-2013).

8.4.1 Southern California Coastal - Index of Biotic Integrity Results

8.4.1.1 Water Quality Sampling 2013-2014

Out of 17 total samples collected during water quality events, seven had over 500 individuals (Table 8-3). These were subsampled to 500 individuals, and were included in statistical analyses. The April 14 SP (300 m) sample was also included (n=492). All were in the Fair to Very Poor ranges. OF (6500 m), the site closest to the town of Topanga and residential development, consistently scored the lowest at 10-18 (Very Poor-Poor). Scratchy Trail (4800 m), which is almost 2,000 m downstream, scored the highest of all samples with a score of 33 (Fair). Further downstream, TB (3600 m) scored a 22 (Poor), and BR (1700 m) scored a 25 (Poor). Both TB and BR are roadside adjacent.

The lowest metrics, consistently across all sites are percent intolerant individuals, and percent tolerant taxa. No significant correlations were found between SCC-IBI total scores and site conditions such as flow, depth, water temperature or dissolved oxygen (regression analysis, significance F >0.05). There was a significant correlation between dissolved oxygen and SCC-IBI metric % non-insect scores in Topanga Creek ($F<0.05$, $r^2=0.52$). In some instances, fecal indicator bacteria correlated with SCC-IBI scores. Average total coliform per site in 2014 (excluding first flush) was significantly and negatively correlated to EPT taxa, and also to total SCC-IBI scores ($F<0.05$, r2=0.88, $r^2=0.64$). Average nutrient levels did not seem to correlate with SCC-IBI scores.

Table 8-3 Topanga Creek WQ sample SCC-IBI metrics and creek conditions 2013-2014.

Sample ID	(n)	%CF+CG	% Non Insect taxa	% Tol. taxa	Coleoptera Taxa	Predator Taxa	% Intolerant ind.	EPT Taxa	SUM (0-70)	Flow (cfs)	Avg Depth (in)	Water Temp (^{o}C)	Avg Algae Cover	DO %	Simpson's DI*
OF0913	500	6	0	0	2	1	0	1	10	0.19	16.2	16.1	0%	64	0.7
OF0414	500	1	5	3	2	4	0	3	18	0.11	14.2	11.9	0%	71	0.5
OF0614	500	4	1	0	2	7	0	3	17	0.23	12.7	15	0.3%	35	0.8
ST0414	500	1	7	2	5	2	1	2	20	0.03	10.1	13.2	0%	76	0.5
ST0614	500	6	7	3	7	6	1	3	33	0.17	13.4	16.5	0%	68	0.9
TB0614	500	10	3	1	2	3	1	2	22	0.04	2	15.8	0.3%	62	0.9
BR0414	500	2	5	2	4	7	2	3	25	0.19	4.1	12.9	100%	76	0.6
SP0414	492	0	0	0	0	1	0	0	1	0.12	3.9	15.5	0%	50	0.1
OF0513	47	6	3	1	4	0	0	0	14	0.30	4.7	13.4	67%	62	0.8
ST0513	178	1	4	2	2	0	0	1	10	0.21	17.2	14.8	0%	83	1
ST0913	71	10	0	0	0	0	0	0	10	0.06	12.5	17.2	0%	76	0.8
TB0513	61	10	4	2	2	0	0	1	19	0.34	3.0	14.8	50%	75	0.8
TB0913	227	10	2	0	2	3	0	1	18	0.05	2.3	16.9	0%	67	0.8
TB0414	341	3	6	1	4	6	3	3	26	0.08	3.9	12.9	19%	74	0.7
BR0513	322	1	7	9	4	2	4	3	30	0.26	5.2	15.1	75%	90	0.4
BR0614	136	4	0	0	4	0	0	0	8	0.10	4.6	15.6	0%	50	0.6
SP0614	354	8	3	0	2	7	0	0	20	0.00	4.0	16.1	0%	47	0.8

Gray cells had n>500 are subsampled for SCC-IBI. SP0414, n=492, was included in statistical analysis.

8.4.1.2 Annual Stream Surveys 2003-2014

Three out of ten of the annual spring stream samples from Lower Topanga (LT; 3200 m) and five out of eight samples from Upper Topanga (UT; 4500 m) had >500 individuals and these eight samples were subsampled to 500 individuals for SCC-IBI scoring.

Overall, there did not seem to be a significant difference between sites, or a trend among sites or years for total IBI scores (Table 8-4). LT scored the highest overall in 2007 (40; Fair). The lowest scores were from LT in 2005 and UT in 2014 (16,15; Poor). There were two years, 2005 and 2014, when enough individuals were collected from both sites so that a comparison could be made. In 2005, UT scored higher (23 vs. 15), whereas in 2014, LT scored higher (19 vs. 15). The lowest metric across all 500 (n) samples was % intolerant individuals, which never surpassed score of 1. Conversely, the highest metric on average was % tolerant taxa. This stands in contrast to water quality samples from 2013-2014, when % tolerant taxa was the lowest. This may be the result of a shift in species composition discussed in Section 9.4.3. No significant correlations between SCC-IBI metrics and recorded creek conditions were found.

Table 8-4 Topanga Creek Annual Stream Surveys SCC-IBI metrics and creek conditions 2003-2014.

Sample ID	(n)	%CF+CG	% Non Insect taxa	% Tol. taxa	Coleoptera Taxa	Predator Taxa	% Intolerant	EPT Taxa	SUM (0-70)	Flow (cfs)	Avg depth (in)	Water Temp (^{o}C)	DO %	WY Rainfall (in.)	Drought Intensity
UT03	500	1	8	10	4	1	0	2	26	0.43	3.9	14.7	90%	17.92	N
UT05	500	0	5	8	4	0	1	5	23	0.34	ND	15.1	69%	61.22	N
LT05	500	3	3	8	0	1	0	1	16	0.16	9.8	17	65%	61.22	N
UT06	500	1	5	5	4	2	0	8	25	0.15	11.3	15.6	100%	20.04	N
LT07	500	5	7	7	7	4	0	10	40	0.05	8.7	ND	ND	4.61	D3
UT10	500	2	8	6	2	5	1	5	29	1.13	9.3	10	ND	24	N
UT14	500	1	4	3	5	0	0	2	15	ND	9.6	6.85	72%	6.85	D3
LT14	500	4	2	2	2	6	1	2	19	0.06	2.2	14.9	76%	6.85	D3
LT03	104	2	7	8	2	1	1	1	22	0.27	8.3	14.6	97%	18	N
LT04	464	5	8	4	4	8	1	1	31	ND	ND	ND	ND	13.16	D0/D1
LT06	398	4	8	6	4	2	1	3	28	0.22	7.6	14.6	96%	20.04	N
LT10	296	2	6	8	0	3	1	4	24	0.1	5.2	10	ND	24	N
UT11	178	0	8	10	0	0	0	2	20	ND	20.9	14.8	95%	31	N
LT11	255	2	6	8	2	0	2	1	21	0.42	11.8	15	100%	31	N
UT12	117	2	6	4	0	3	0	2	17	0.04	7.1	14.1	100%	15	D0
LT12	208	2	6	4	2	2	0	1	17	0.21	6.9	15.3	100%	15	D0
UT13	308	3	1	0	2	1	0	2	9	ND	5.5	9.44	78%	9.44	D1
LT13	371	1	5	5	4	1	0	3	19	0.03	3.5	14.7	91%	9.44	D1

Gray cells had n>500 are subsampled for SCC-IBI. SP0414, n=492, was included in statistical analysis. ND = no data

8.4.2 Taxa Composition and Diversity Measurements

8.4.2.1 Water Quality Sampling 2013-2014

In addition to SCC-IBI, taxa composition was analyzed and diversity measurements applied. Between Owl Falls (6500 m) and Snake Pit (300 m), taxa composition varied over time and reach (Figure 8-2), however Functional Feeding Group (FFG) composition was more consistent. Potential links between BMI community and water quality conditions are included in the following results, organized by site.

Starting with Owl Falls, the BMI community was dominated (Relative Abundance (RA) >50%) by planktonic crustaceans, Amphipoda (freshwater shrimp) and Ostracoda (seed shrimp), except in April 2014 where a Chironomid (non-biting midge) larvae bloom dominated all six sites. Oligochaeta and Planarian (flat and segmented worms) were present in high numbers in September 2013 and June 2014, 21-24% RA respectively. Other insect taxa (EPT, Coleoptera) at Owl Falls occurred in much smaller numbers (average RA <5% for all four dates). Insect taxa present all four months at OF include the nymphs or larvae of Leptohyphidae (Tolerance value (TV) =4), Haliplidae (TV=7), and Hydroptilidae (TV=6).

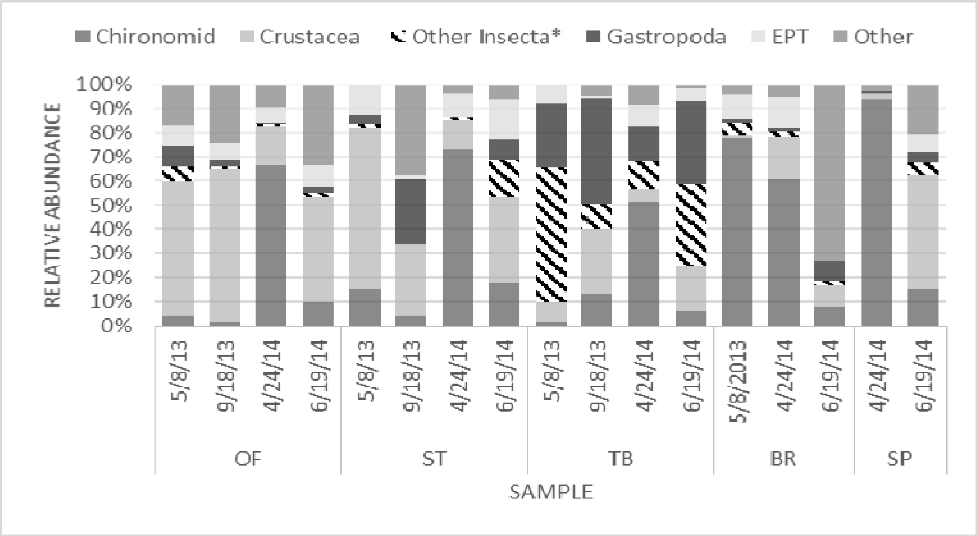


Figure 8-2 Relative Abundance of six major categories at OF, ST, TB, BR, SP.
*Other Insecta includes Coleoptera and Plecoptera. Crustacea includes Amphipoda and Ostracoda.

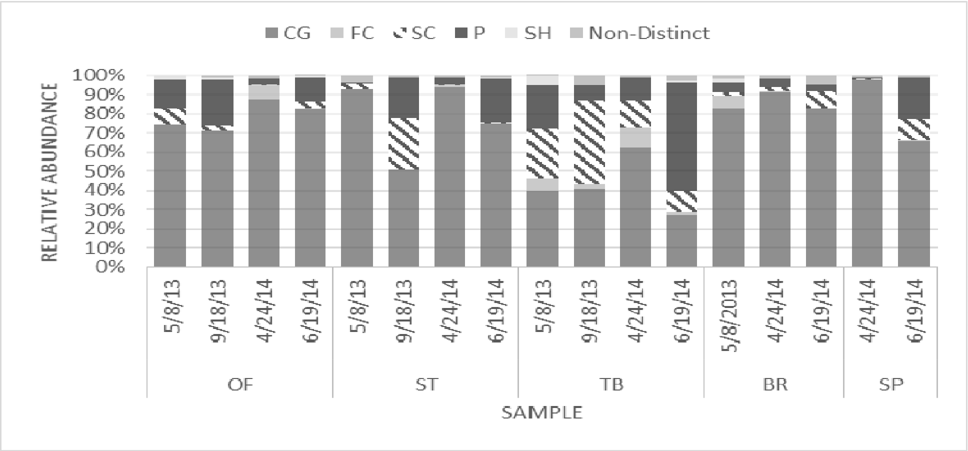


Figure 8-3 Relative abundance of functional feeding groups at OF, ST, TB, BR, SP.

Leptohyphidae, or little stout crawler mayflies, have gills that are specialized for waters that are warm, silted, and/or have low-dissolved oxygen (Voshnell 2002). Dissolved oxygen levels at OF was relatively low, measuring 35-71%. While mayflies are usually an indicator of good water quality, Letohyphidae is an exception (Voshnell 2002). Other exceptions include Caenidae and Baetidae, which comprise the majority of Ephemeroptera in Topanga Creek. While average depths from 9/13 to 6/14 were relatively high (12.7-16.2 in) levels in 5/13 were as low as 4.7 in, flow varied from 0.11-0.18 f^3s. Haliplidae, crawling water beetles, are often associated with macroalgae like *Chara*, and Hydroptilidae (microcaddisflies) with filamentous algae, both potentially indicative of nutrient pollution. An algae bloom was observed in August 2014. OF did have the highest average ppm nitrate (0.06) and orthophosphates (0.19) across all sampling dates (Table 6-11 and Table 6-14, respectively).

Both Owl Falls (6500 m) and Scratchy Trail (4800 m) simultaneously experienced Ostracoda (May '13) and Amphipoda dominance (Sept '13), when neither taxon prevail downstream, suggesting some level of connectivity between sites. Three out of four months ST had the highest Simpson's Diversity Index (Figure 8-4), primarily due to greater species evenness. Plankton remain highly abundant overall. Insect taxa that were present in at least 75% of ST samples include Leptohyphidae, Baetidae, Elmidae, Hydroptilidae, and Ceratopogonidae. While these additional taxa are also present in Owl Falls, their increased abundance at Scratchy Trail may illustrate improved habitat conditions. Dissolved Oxygen at ST was measured between 76-83%, and average depth 10.11-17.2 in on sampling days. The highest SCC-IBI scores in April and July 2014 (20, 33) support this observation.

Topanga Bridge (TB) had the most stable Simpson's Diversity Index (Figure 8-4) and SCC-IBI scores (18-26). Although water levels at TB were low (2-3 in.), DO remained

62-75%. TB has the first or second highest SCC-IBI scores in April and July 2014. One of three Gastropoda families are the first or second most abundant taxa each month, *Physa sp*. (5/13), Hydrobiidae (9/13,4/14), and Viviparidae (6/14). Odonata diversity is also higher at TB, with nymphs of the three genera: *Argia sp*., *Enalgamma sp*., and *Libellulidae sp*. In May 2013, Elmidae 'riffle beetle' larvae, comprised 30% relative abundance. Elmidae require high levels of dissolved oxygen and are found in waters with near saturation. Plecoptera, a family synonymous with good water quality, makes its first appearance at TB in the form of *Ispoerla sp*. nymphs (common stoneflies) collected 6/19/14.

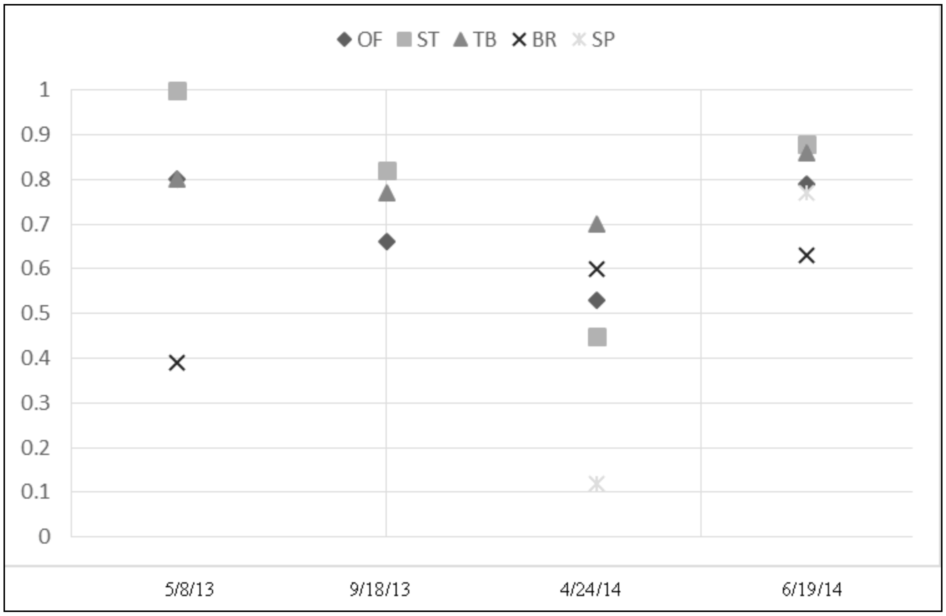


Figure 8-4 Simpson's Diversity Index scores for Source ID sites May 2013-July 2014.

At Brookside (BR 1700 m), which went dry in September 2013, mosquitoes or non-biting midges dominated in each sample. After water returned, *Culex sp*. larvae comprised 60% RA in July 2014. At that time, DO hit a low of 50%. Many species of Culicidae prefer temporary habitats. BR had the highest levels of Ammonia (average 0.27 ppm), potentially due to the consistent dumping of urine waste by an RV along Topanga Canyon Blvd above the site (Figure 6-2). Culicidae reproduction and Chironomid abundance have been observed to increase in Southern California wetlands enriched with ammonia (Sanford et al. 2005). While both of these Dipteran taxa are tolerant of nutrient enriched waters, other less-tolerant taxa also are found at BR. Nemourid stone fly nymphs, and Carabidae 'ground beetle' larvae with a tolerance value 4, each made up 2% RA in May 2014.

Snake Pit, sampled only in April and July 2014 also displayed variability. In April, SP had the lowest SCC-IBI and Simpson's Diversity score of 1 (Very Poor). All 16 taxa found at this time were from Diptera, Hemiptera, or non-insect; Chironomidae composed 94% RA. In July 2014, scores improved, although no significant site condition changes occurred. Chironomidae RA was reduced to 15%, while Ostracoda made up 24%, and Simpson's Diversity Index increased (from 0.1 to 0.8). In addition to the previously sampled families/phylums, Trichoptera, Odonata, and Coleoptera appeared in July. According to Bray-Curtis analysis that was applied to eight primary taxa groups, samples taken from all sites on the same date had a higher similarity (37%) than those taken from the same site across four dates (27%). This trend holds true for FFG composition as well. This suggests homogeny throughout the system. Additionally, the similarity coefficient between FFG composition (Figure 8-3) across both time and place, was significantly higher than taxa composition (t-test, $p<0.05$). This upholds the findings of Vannucchi et al. (2013) that feeding niches filled by benthic macroinvertebrates may remain filled, even though the specific species change. Therefore, systematic stability of nutrient flow and energy flux may remain, even without stability of distinct species populations.

8.4.3 Annual Stream Surveys 20013-2014

The number of individuals collected from the annual spring stream surveys from Upper and Lower Topanga Creek ranged from 104 to 3,516, representing six phyla, 21 orders, and a total of 76 taxa. The majority of individuals fell within the phylum Arthropoda and class Insecta, followed by the subphylum Crustacean, including class Ostracoda and order Amphipoda. To date, the invasive New Zealand mud snails (*Potamopyrgus antipodarum*) have not been observed in Topanga Creek.

Between 2003-2012, *Baetis sp.* (blue-winged olives), a prolific genera of small minnow mayfly, was the first or second most abundant taxon every year in both Upper and Lower reaches (Figure 8-5). *Baetis sp.* made up between 33-79% relative abundance (RA) in Upper Topanga, and 13-67% in Lower. The family Baetidae are characterized as strong swimmers, most prevalent in flowing, shallow waters with ample cobbles and/or pebbles (Voshell 2002). *Baetis sp.* are collector-gatherers with a tolerance value of 6. In 2013 and 2014, *Baetis sp.* no longer dominated and in fact comprised less than 10% RA of all four samples. Chironomidae, which had previously made up between 5-36% shifted to occupy the top spot, comprising 63-72% of all samples in 2013-2014. Chironomids are also primarily collector-gatherers, and are ascribed a family-wide tolerance value of six. However, the Chironomidae family is extremely diverse, including over 1,000 species, and thrive in equally diverse habitats. Chironomids were identified to sub-family or tribe for a few select samples, and similar taxa were found before and after 2013.

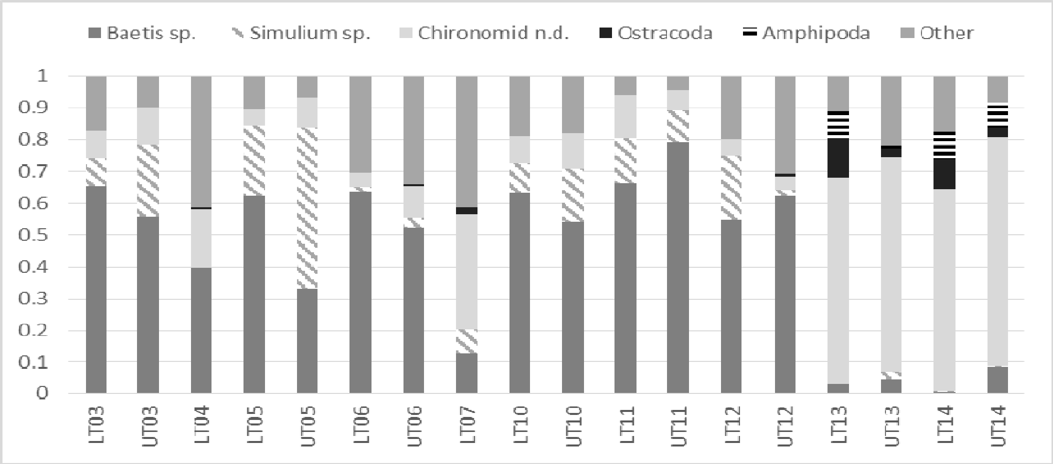


Figure 8-5 Relative Abundance of 6 Major Taxon Categories: Upper and Lower Reaches Topanga Creek 2003-2014.

Two concurrent phenomena occurred between the 2003-12 period as compared to 2013-14. Between 2003-12 *Simulium sp*. (a member of the black fly family) was present in all six Upper Topanga samples with an average relative abundance 18%, and 12% in seven out of eight Lower Topanga samples. However, in 2013 and 2014 *Simulium sp.* made up only 2% average relative abundance in Upper Topanga, and were not present at all in Lower samples. Simulidae, which occur only in flowing waters (Voshnell 2002), are collector-gatherers, with a tolerance value of six.

Another stark difference between 2003-12 and 2013-14 was the presence of Amphipoda or 'scuds.' A subsample of scuds were identified to be of the family Hyallelidae. Of all 14 samples from 2003-12, Amphipods were only found in Upper 2003 at 0.13% RA. Beginning in 2013, scuds appeared again at 1-8% RA (Upper-Lower), and jumped to 3-29% in 2014. Scuds are bottom-dwellers and are rarely found in waters deeper than 1 m (Voshnell 2002). Scuds are predominantly collector-gatherers, and have a tolerance value of eight. Scuds are most often found in large numbers where fish are not present, as they are a preferred food source. However, snorkel survey observations document that fish are present at all sampling sites (RCDSMM, *unpublished data*), and thus they are either not selectively preying upon scuds, or the reproductive rate of scuds exceeds the predation rate. Despite these changes, functional feeding group composition remained dominated by collector-gatherers. (Figure 8-6) There may be a decline in evenness of FFG in 2013-2014.

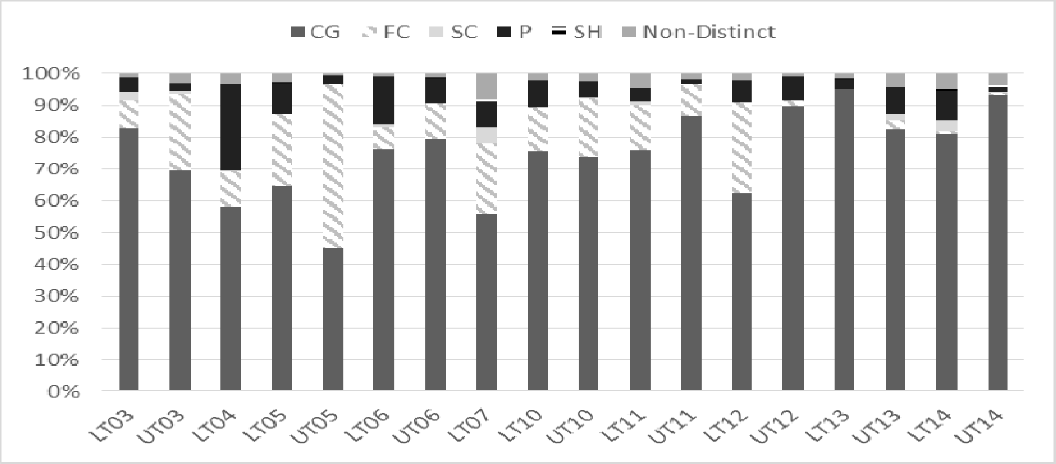


Figure 8-6 Relative Abundance of 6 Major Feeding Group Categories: Upper and Lower Reaches Topanga Creek 2003-2014

Bray-Curtis analysis of dissimilarity points to a trend between rain patterns and BMI species composition in Topanga Creek (Figure 8-7). Excluding the two wettest years (rainfall >30 inches), analysis of the annual stream survey samples showed that the dissimilarity coefficient (how different from all other years) was negatively correlated to rainfall (regression test, significance $F<0.05$). This suggests a threshold equal or less to 30 inches, over which high rainfall also disturbs BMI communities.

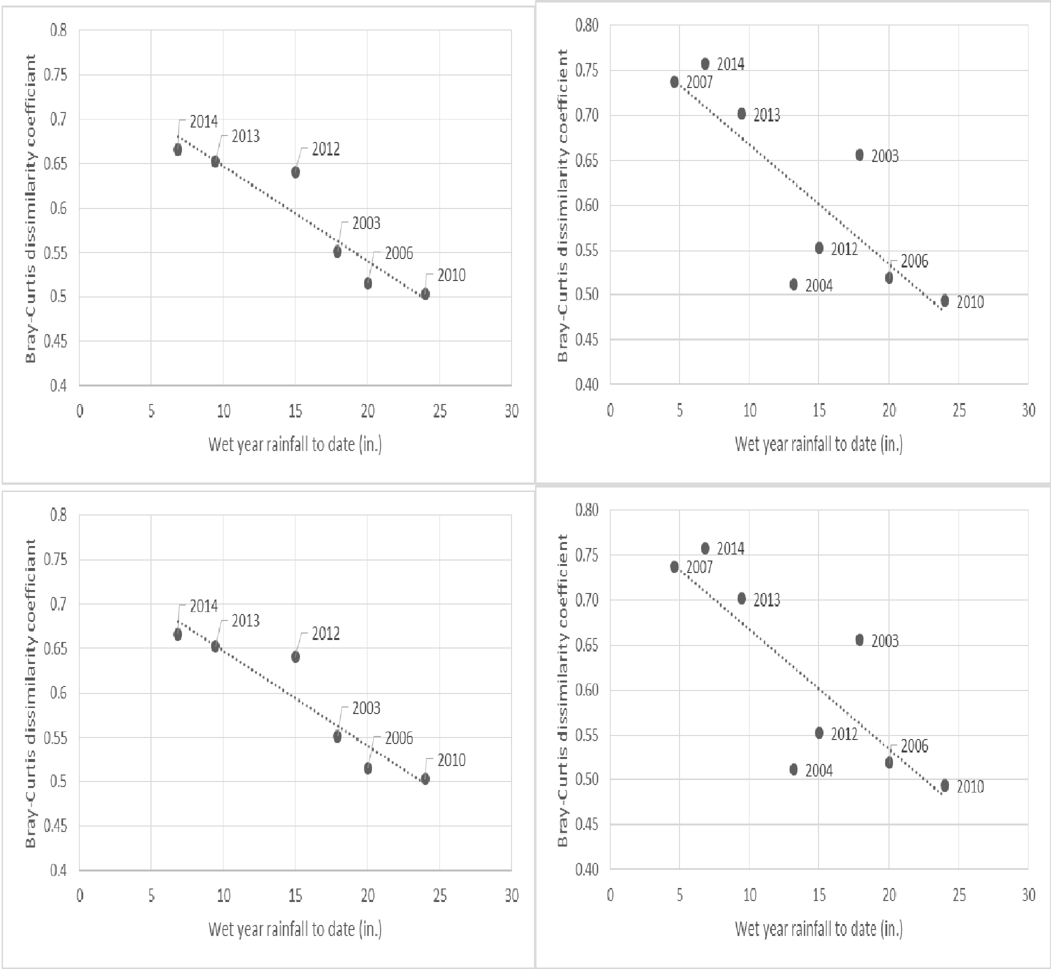


Figure 8-7 Rainfall vs. Curtis-Bray dissimilarity coefficient Upper (left) and Lower (right) Topanga. (R^2 = 0.88, 0.67 respectively)

8.4.4 Comparison of Topanga Creek IBI with other Santa Monica Bay sites

Although this study focused on Topanga Creek specifically, Heal the Bay has monitored BMI at a variety of locations within the Santa Monica Bay since 2000 (Figure 8-1). Table 8-5 summarizes the SCC-IBI information for sites considered to be reference (Arroyo Sequit AS19, and Cold Creek CC2, CC3, CC11) as well as for Malibu Creek (MC1, MC 15), which represents the more impacted reaches of lower Malibu Creek downstream of the Tapia Wastewater Treatment Plant that also support a population of steelhead trout.

SCC-IBI scores in Malibu Creek remained low since 2000, but reference sites such as those in Cold Creek, Solstice and Arroyo Sequit showed declines beginning in 2012. This regional pattern may be a reflection of the drought conditions affecting all local streams. Topanga Creek faced a sharp decline in SCC-IBI scores after 2001. The current drought period began in January 2002 entering a period of D0 intensity: ‘abnormally dry;’ and by mid 2002 the drought reached a level of D2: ‘severe drought’ until the winter rains in November 2002 (US Drought Monitor). It is not clear why scores in Topanga Creek began to fall in 2002, but this did not become apparent in other creeks until 2012. Although Topanga Creek is facing severe impacts from drought, reflected both by SCC-IBI scores and BMI species composition, it remains an important reference stream as it continues to flow where others in the region have gone dry.

Table 8-5 Adjusted[1] IBI Scores for Topanga and surrounding creeks 2000-2013.

SITE	Spr. 2000	Spr. 2001	Spr. 2002	Spr. 2003	Fall 2003	Spr. 2006	Spr. 2008	Spr. 2009	Spr. 2010	Spr. 2011	Spr. 2012	Spr. 2013	
Rainfall		**27.8**	**7.24**	**17.92**	**17.92**	**21.98**	**23.08**	**16.16**	**24.4**	**31.44**	**16.22**	**9.99**	
Malibu Creek													**Av.**
MC1	16	26	19	26	23	26	20	27	6				21
MC15	33	24	40	34	23	17		18	6	16	13	17	22
Cold Creek													
CC2	36	46	53	44		31/42		27	20	19	36		35
CC3	80	92	83	84	64	73	67	79/80	82	66	76	50	74
CC11	54	56	49	40		47		57	37/43	67	51	45	52
Solstice Creek													
SC14			76	67	70	60	56	69	49	59	72	60	64
Arroyo Sequit Creek													
AS19			72	72	70	57	50	70	70	64	56	40	62
Topanga Creek													
LT		66*		31*	44*	40*			34*	30*	24*	27*	37
UT		66*		37		36			41	29*	24*	13*	35

[1] *Scores are adjusted to to fit a scale of 0 to 100. *Denotes samples n<500*

8.4.5 Annual stream survey correlation to rainfall

During the course of the annual sampling in 2013 and 2014, water levels were consistently low, with little to no flow observed. While flow was not correlated to SCC-IBI scores, low dissolved oxygen levels did correspond to higher percentage of non-insect taxa, which did in turn lower overall SCC-IBI scores. Comparing scores with yearly rainfall to date, SCC-IBI scores 2003-2014 do not show any correlation. However, the observed shift in species composition from *Baetis sp./Simulium sp*. to Chironomid nd.

/Amphipod nd. occurred between 2012 and 2013. That winter was the first year since at least 2000 when wintertime rains did not alleviate drought conditions in the upper Santa Monica Bay. Drought intensity remained at D0: 'Abnormally Dry' or higher through the wet season, signaling an intensification of drought conditions in Los Angeles County (US Drought Monitor 2014).

8.5 Discussion

Benthic macroinvertebrate bioassessment of Topanga Creek at five water quality sites (2013-2014) provided additional insight to the biotic implications of water quality conditions. SCC-IBI scores indicated that the biotic integrity was lowest just below the town of Topanga at OF (6500 m). The highest scores were found at ST (4800 m), which was the only location to receive a 'Fair' rating. Without the anthropogenic influences of land grading, road or building development, ST is the least human-influenced site in the study. Simpson's Diversity was also highest at ST, due to a higher abundance of multiple taxa creating a more even distribution. This marked increase in biotic integrity suggests that water quality improves as water moves through the watershed from 6500 m to 4800 m. However, the high relative abundance of non-insects and dearth of low-tolerant taxa throughout the system support more consistent 'poor' SCC-IBI ratings further downstream, and suggests overall habitat degradation or disturbance.

Observed creek conditions that may influence these low scores include the input of fecal indicator bacteria, low dissolved oxygen, nutrient enrichment, and drought. Sites with higher average total coliform levels had significantly lower SCC-IBI total and EPT taxa scores. Low dissolved oxygen was found to correlate significantly with higher % non-insect taxa. The site (OF) with the highest average levels (ppm) of nitrate and orthophosphates, received the lowest SCC-IBI scores. High levels of ammonia, in conjunction with drought-related drying events likely created ideal habitat conditions for high abundance of mosquitoes (Culicidae) and midges (Chironomidae) at BR (Sanford et al. 2005).

Based on the Bray-Curtis analysis, samples collected on a particular date at all sites throughout the creek are significantly more similar to each other than samples collected at a single site over time. This suggests that although site conditions may influence the BMI community throughout Topanga Creek, overall system homogeny creates an environment in which cumulative effects over time may be a stronger driving force than location within the creek.

SCC-IBI scores for annual stream survey samples (2003-2014) found that Topanga Creek's lowest integrity metrics is percent intolerant individuals. Throughout this period, the percent tolerant taxa was the highest metric score, as the system was not dominated by pollution-tolerant organisms. However, when looking at the 2013-2014 water quality samples collected throughout the creek, the percentage of intolerant taxa remained the lowest and the percentage of tolerant taxa fell to the second lowest score. This suggests a shift to increased abundance of pollution tolerant organisms. Also, a drastic species composition change observed in the annual stream survey samples between 2012 and 2013 from *Baetis/Simulium* to Chironomid/Amphipoda signals a system-wide disturbance or condition change. Drought conditions did intensify between 2012 and 2013, as winter rains failed to alleviate drought conditions for the first year in at least a decade.

Future sampling to determine if this condition is persistent year-round or due to springtime blooms that correspond with sampling events should be considered. *Baetis* and Chironomids are both short lived species that can produce multiple generations per year in the Southwest; some species of *Baetis* complete their life cycle in 8-14 days (Gray 1981). Some species rely on specific life cycle cues, with only 1-2 generations a year, and so phenology changes could be potential driver of this observed phenomenon. Recent work has found that increasing water temperatures can induce earlier hatches of *Baetis* in the Western United States (Harper et al. 2006). Further analysis of water temperatures in Topanga Creek is recommended. The shift from *Baetis* dominance to Chironomids could also reflect a change in physical habitat conditions. The replacement of *Simulium sp*. with Amphipoda, particularly in Lower Reach samples, supports this hypothesis.

Our data suggested a correlation between community stability and rainfall. Years with low rain were more dissimilar than those with more rain. However, this no longer holds true with rainfall over 30 inches, suggesting that both drought and heavy flows can create disturbance to the BMI community.

In comparison with nearby creeks, including Malibu Creek, Cold Creek, Solstice, and Arroyo Sequit Creek, SCC-IBI BMI scores for Topanga from 2003-2013 are relatively low (Table 8-5). Topanga Creek remains one of the few perennial streams within the Santa Monica Mountains while many of these other locations are dry for much of the year. Although the SCC-IBI scores are low, the year round water in Topanga Creek supports a more complete assemblage of native amphibians and fish. It is difficult to explain why Arroyo Sequit, another perennial system that goes dry regularly, out-performs Topanga Creek by over 25 points on average.

The main limitation of applying the SCC-IBI metrics within this sample set was low abundance, as the majority (19 of 35) of our samples had fewer than 500 organisms. Seasonal variability within Mediterranean climates can be driven by short-term climatic factors and can vary greatly creating distinct seasonally-based communities (Gait and Resh 1999). However, It is important to note that it has been suggested that bioassessments like SCC-IBI may be less applicable to perennial streams, as survival in degraded streams requires many of the same life-history traits that also support survival of benthic macroinvertebrates in non-perennial streams (Mazor et al. 2013).

8.6 Summary

- Owl Falls was consistently the lowest SCC-IBI scores, and Scratchy Fall the highest. This may be a result of proximity to development.
- Average total coliform per site in 2014 corresponded to lower total and EPT taxa SCC-IBI scores.
- The SCC-IBI metric percentage of non-insect taxa is significantly higher when levels of dissolved oxygen are lower.
- Samples from a particular site were less similar, overall, than samples from the same date, suggesting homogeny throughout the creek.
- Functional feeding group composition was more stable than taxa composition per site and over time.
- Regional comparison of Topanga Creek indicated relatively degraded conditions.
- Both high and low flow conditions resulted in disturbed BMI communities.
- Worsening drought conditions during the winter 2012/13 may be causing a significant shift in species composition in Topanga Creek.

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9 Red Swamp Crayfish (*Procambarus clarkii*) In Topanga Creek: Removal Efforts And Ecosystem Effects

9.1 Abstract

The presence of invasive red swamp crayfish (*Procambarus clarkii)* in Topanga Creek was first recorded in 2001. The population has since increased, with a population explosion in 2011, during an extended period of low flow. Within the Santa Monica Mountains, *P. clarkii* has been linked to diminishing numbers of California newt (*Taricha torosa*), a species of special concern (Katz 2013). To address these concerns, a student citizen science program was conducted from September 2013 through February 2014 to remove crayfish from a 200 meter reach of Topanga Creek. The following metrics were collected and compared between the removal reach and an upstream, adjacent 200 meter non-removal reach: water quality (temperature, salinity, pH, conductivity, dissolved oxygen, turbidity), nutrient levels (nitrate, nitrite, ammonia, orthophosphate), crayfish abundance, and macroinvertebrate communities. The following metrics were collected within the Removal Reach: catch per unit effort, average crayfish length, and sex distributions of removed crayfish. The results indicate that the effects of crayfish on nutrient levels are low or non-existent; however, the presence of crayfish seems to correlate with lower BMI biodiversity. This study was conducted to gain a better understanding of the effects of *P. clarkii* in the Topanga Creek ecosystem.

9.2 Introduction

Red swamp crayfish (*Procambarus clarkii*) have spread far across the globe, posing an invasive threat to freshwater species abundance and community diversity (Ficetola et al. 2011). Without checks to their population, red swamp crayfish easily become a threat. They can grow rapidly, maturing within three months after hatching and can reproduce twice a year in warm conditions (Barnes 1974; Vodopich and Moore 1999; Safra et al. 1999). Furthermore, large healthy females typically produce 600 viable young (Barnes 1974; Vodopich and Moore 1999; Safra et al. 1999). The generalist and predatory feeding habits of this Gulf Coast native have been linked to observed declines in macrophyte abundance (Feminella et al. 2006; Rodriguez et al. 2005), macroinvertebrate diversity (Correia et al. 2008), increased bioturbation (Mueller 2007; Yamamoto 2010), and amphibian species richness and recruitment (Gamradt and Kats 2002; Cruz et al. 2006; Ficetola et al. 2011). *P. clarkii* consume an array of plant and animal matter, aquatic vertebrate eggs and larvae, aquatic invertebrates, and can affect food webs on a polytrophic scale. In Northern Italy, Ficetola et al. (2011) found that the presence of crayfish reduces the number of newt, salamander, toad, and tree frog breeding sites. They concluded that many of these amphibians actively avoid crayfish infested waters. For individuals that remained to breed, there was a negative association between larval abundance and crayfish presence across all seven species sampled. Pease and Wayne (2013) also observed that Pacific tree frog tadpoles (*Pseudarcris regilla*) responded to predation by crayfish both behaviorally and morphologically by selecting for deeper tail muscles. Gamradt and Kats (2002) conducted amphibian surveys from 1981-1986, and identified 10 Santa Monica Mountain streams supporting populations of California newts. When the surveys were repeated in 1994, newts were missing from three of those 10 streams. Further study documented that *P. clarkia* consumed newt egg masses, as well as attacked adults (RCDSMM *unpublished data*). It was also observed that adult newts recolonized a stream if the crayfish were removed by winter storms and there was sufficient water flow (Gamradt and Kats 2002).

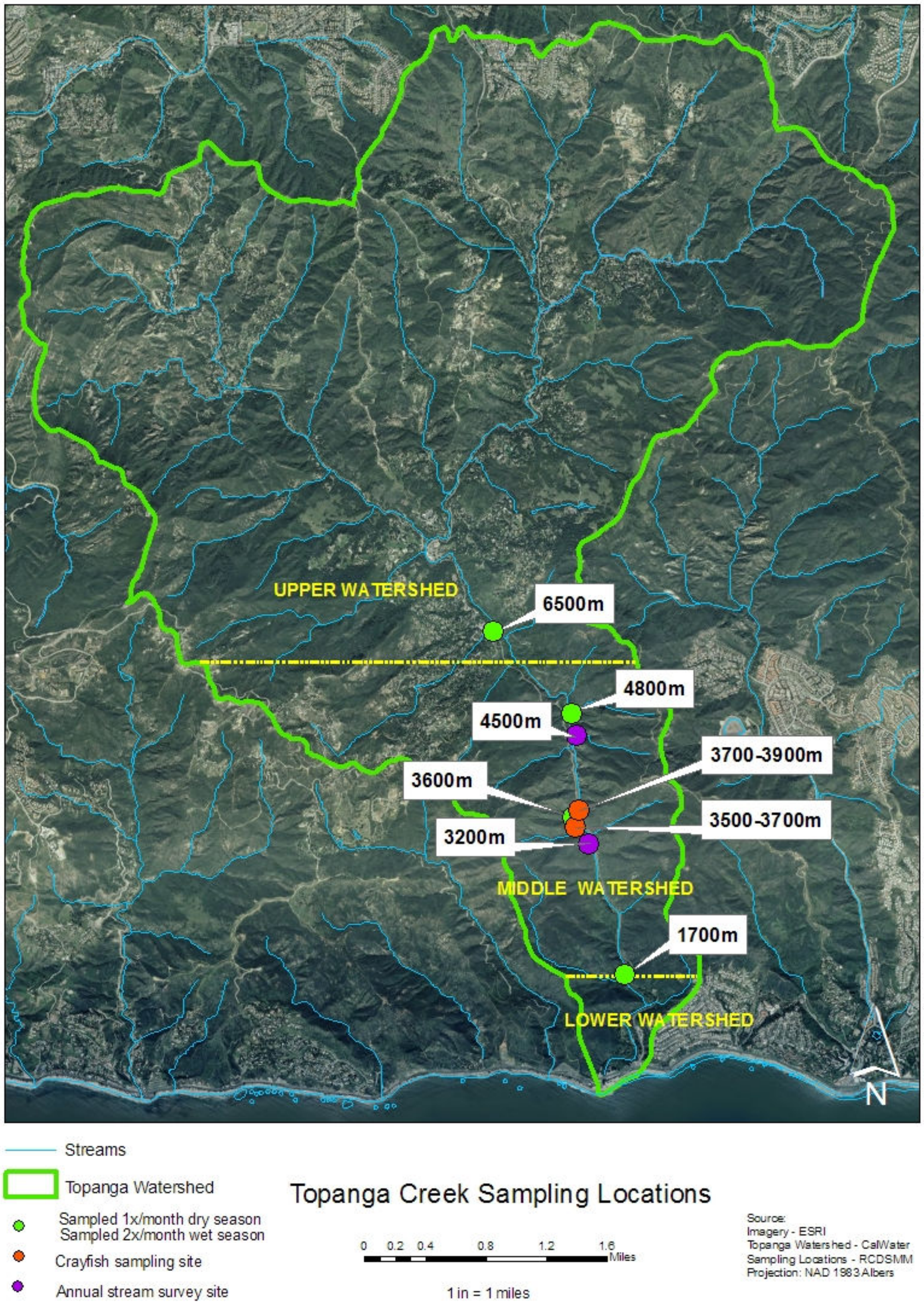
P. clarkii entered southern California as early as 1924 (Holmes 1924), although they were not observed in Topanga Creek until 2001 (RCDSMM *unpublished data*). The crayfish population in Topanga Creek was limited in the first five years by active removal efforts and wintertime rain events, with significant flows that have been shown to be sufficient to wash crayfish from the system (Kats et al. 2013). As the Mediterranean climate eased into drought in 2011, the population expanded rapidly (RCDSMM *unpublished data*).

Environmental conditions of Mediterranean wetlands in periods of drought are a preferred habitat for *P. clarkii* (Geiger et al. 2005). This habitat was characterized by low-flows, shallow water of depths between one and two meters (Voshell 2002), and optimal water temperatures of 25^{o} Celsius (Invasive Species Compendium 2013). The introduction of *P. clarkii* in Topanga Creek raised concerns about possible implications for two sensitive native species, the California newt (*T. torosa*, CA state species of special concern) and southern California steelhead trout (*O. mykiss*, federally endangered). In September 2013, the Resource Conservation District of the Santa Monica Mountains (RCDSMM), in conjunction with the Watershed Stewards Project, launched a citizen science program to remove crayfish from a 200 meter reach of Topanga Creek and monitor crayfish dynamics, water quality, nutrients, and benthic macroinvertebrates.

The goals of this project were to (1) intensively remove crayfish from several refugia pool and step-pool habitats within a 200 meter stretch of Topanga Creek (2) record changes in water quality (dissolved oxygen, pH, salinity, conductivity, turbidity, water temperature) and nutrient levels (nitrate, nitrite, ammonia, orthophosphate) within the study reaches, and (3) measure the benthic macroinvertebrate community composition.

Study Area

Topanga Creek (34º 6’11”N 118º 36’18” W, elev. 1 to 6%) is the mainstem of a small coastal watershed (approximately 47 km^2) located within the Santa Monica Mountains National Recreation Area in southern California. The study reach consisted of 400 continuous meters of Topanga Creek, starting at 3500 meters and ending at 3900 meters from the ocean at a 61.96 meter elevation; this is considered a low elevation (Cuellar and Underwood 2012). The study area is relatively uniform in its geomorphological features, including pools, step-pools, runs, and riffles. This 400 meter stretch was split into a downstream 200 meter crayfish Removal Reach (RR), and the upper 200-meter Non-Removal Reach (NRR). No barriers of any sort were incorporated into the study reaches however natural low flow boulder barriers separated the RR from the NRR.



Source:
Imagery - ESRI
Topanga Watershed - CalWater
Sampling Locations - RCDSMM
Projection: NAD 1983 Albers

Figure 9-1 Topanga Creek Watershed and the Crayfish Study Reaches. The red points represent the study Removal Reach (3500-3700m) and Non-Removal Reach (3700-3900m).

9.3 Methods

Water quality, nutrient, and benthic macroinvertebrates (BMI) samples were collected and samples were analyzed for both 200 meter reaches in conjunction with ten volunteer events between September 2013 and February 2014. Due to the presence of federally listed southern steelhead trout, it was not permitted to set traps of any kind and removal was restricted to supervised hand capture only. Volunteers removed crayfish throughout the 200 meter RR using 3 inch pieces of hotdogs attached to hemp strings. Once crayfish held on to the bait, volunteers would slowly pull them out and net them. The crayfish were then counted, sexed, and measured in centimeters from head to tail using standard rulers. The crayfish were donated to a local wildlife rescue or used for educational purposes. Removal efforts occurred on the following dates: 09/21/2013, 10/11/2013, 11/12/2013, 11/26/2013, 12/03/2013, 12/17/2013, 01/07/2014, 01/21/2014, 01/28/2014, and 02/04/2014.

Water quality samples were collected from three similar pools within each 200 meter reach. An hour prior to each of the removal effort events, each site was tested for air temperature (mercury thermometer), salinity (ATC 300011 SPER SCIENTIFIC salt refractometer), pH (Waterproof pHTestr 30), conductivity (Waterproof ECTestr11), and dissolved oxygen (DO) and water temperature (YSI 55 dissolved oxygen meter). All probes were calibrated within a week prior to the collection date.

Nutrient sampling was conducted once a month from November 2013 through April 2014 at 3600 m, located midway between the RR and NRR sites. Samples were tested for nutrients within eight hours of collection using a LaMotte SMART3 colorimeter and LaMotte 2020we turbidity meter. Samples were tested for nitrate-N, nitrite-N, ammonia-N, orthophosphate and turbidity.

Benthic macroinvertebrate (BMI) samples were collected according to California's Rapid Bioassessment protocols (Ode et al. 2005) in November 2013, December 2013, February 2014, and April 2014 at similar pools and riffles for each 200 meter reach using D-Shape kicknets. Each sample was composed of a total of nine kicks (three transects and three kicks per transect). Samples were preserved in 95 percent ethanol or frozen within eight hours from the collection time and processed and analyzed within a month from the collection date. Most BMI were identified to the family or genus level using a 40x magnification, dissecting microscope.

Using the NRR as a control, t-tests were used to determine any correlation between crayfish presence and water quality, nutrient levels, and BMI presence in Topanga Creek. The Southern Coastal California Index of Biotic Integrity (SCC-IBI) metrics were applied to every BMI sample collected for the study (Ode et al. 2007). In addition to the

SCC-IBI, the total number of individuals, total number of taxa, dominant taxa, percent dominant taxa, percent collector-gatherer, percent filterer-collector, percent scraper, percent predator, percent shredder, average tolerance value, number of Ephemeroptera taxa, number of Plecoptera taxa, and number of Trichoptera taxa were also calculated. However, none of the NRR samples contained 500 individuals as required by the SCC-IBI metrics. As a result, the NRR samples were pooled into one data set and the RR into another. After pooling, the data sets were sub sampled, using Excel and a random number generator to select 500 individuals and perform more reliable SCCI-IBI metrics and scores.

9.4 Results

9.4.1 Removal Effort

The ten volunteer events resulted in a total of 203.25 person-hours and a total of 345 crayfish removed (Figure 9-2); 166 females and 179 males (Figure 9-3). Measurements were taken midline from the tip of the rostrum to end of the tail. The average length of crayfish removed was 7.61 centimeters, and there was no significant difference in length between males and females (p= 0.733) or statistical trend in the length of crayfish over time (R^2=0.008). There was also no significant difference found between the number of females and males caught.

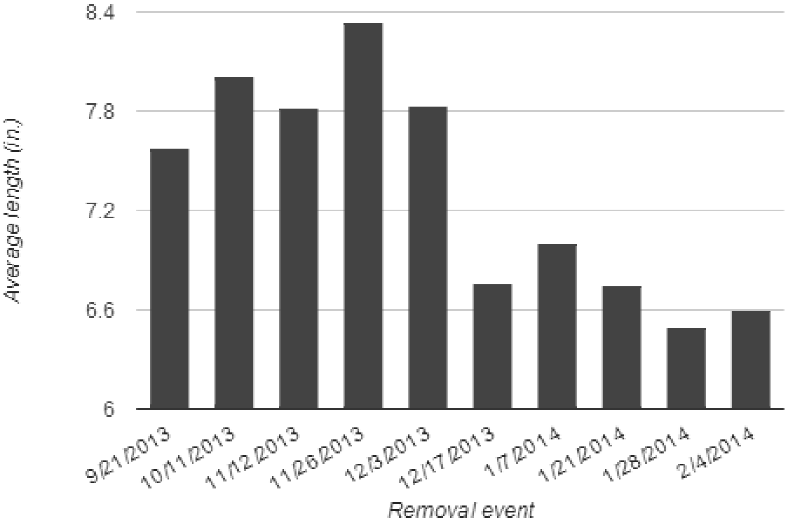


Figure 9-2 Average Length of Removed Crayfish by Event.

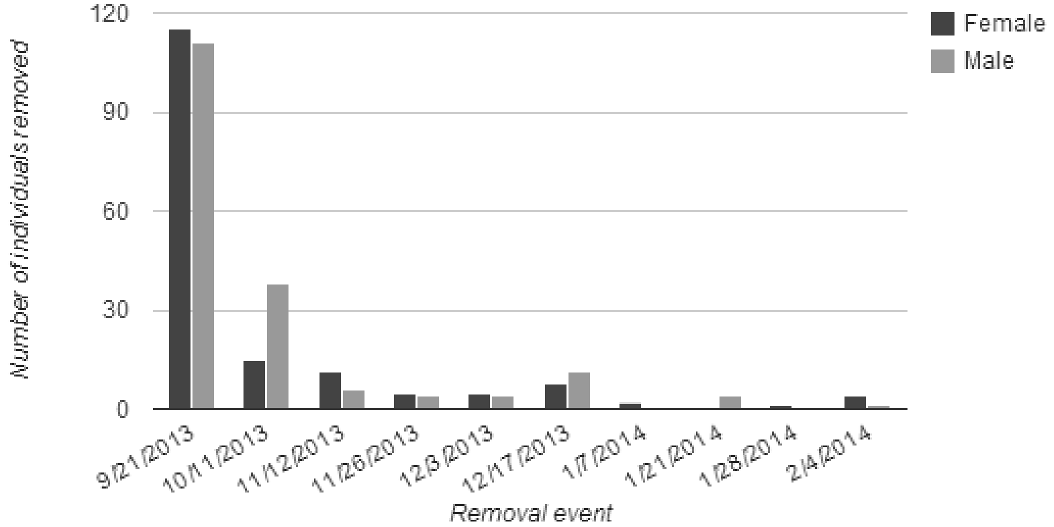


Figure 9-3 Number of Male Versus Female Crayfish by Event.

The catch per person per hour declined from 2.26 crayfish to 0.83 over the course of study. No statistical trend was found linking removal efforts to the decrease in the catch per person per hour (R^2 =0.315) (Figure 9-4). Water temperatures and catch per person per hour were found to have a correlation coefficient of 0.726, but had an R^2 value of 0.173 that suggests an unreliable best-fit line (Figure 9-5). However, as water temperature cooled fewer crayfish were observed and were more difficult to capture.

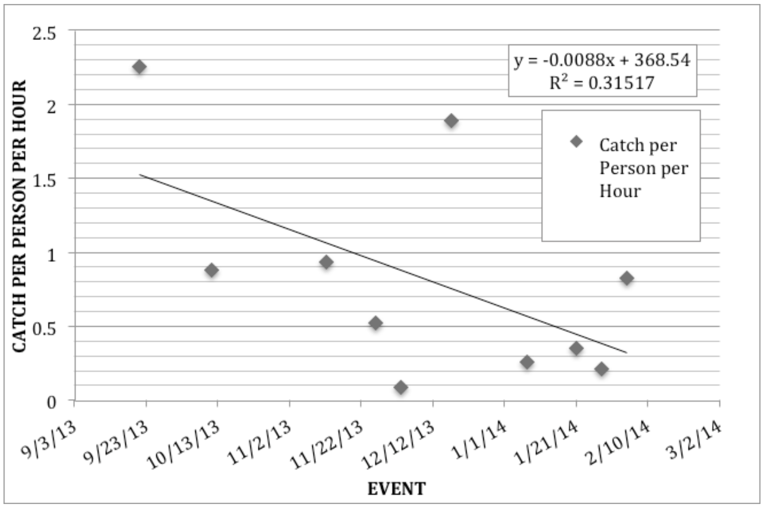


Figure 9-4 Catch Per Person Per Hour Over Time.

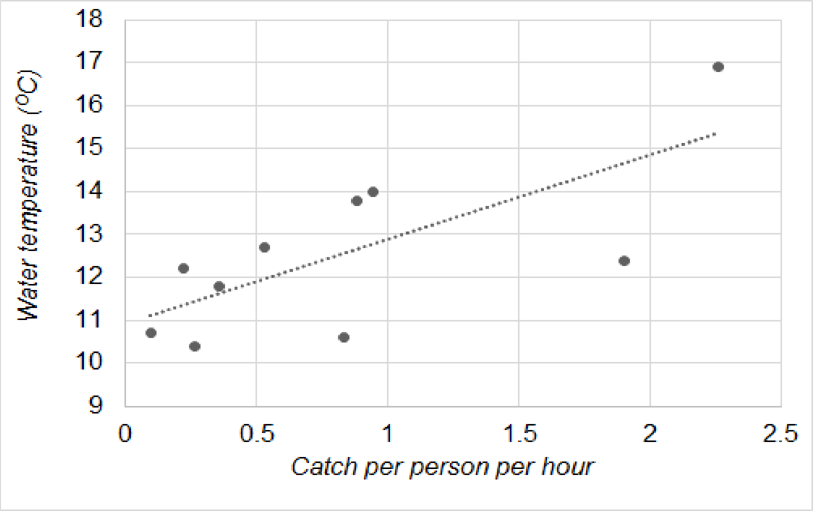


Figure 9-5 Catch Per Unit of Effort Versus Water Temperature.

9.4.2 Water Quality and Nutrients

Water quality and nutrient data were compiled into a database. The data was analyzed for any significant difference between the RR and NRR. None of the parameters showed a statistical difference or a general trend, except for salinity. A significant difference of 0.000011 ($P<0.05$) in salinity levels was found, with higher salinity in the non-removal reach (Figure 9-6). However, the salinity levels do not correlate with crayfish removal; the crayfish catch per event were plotted against salinity for the reach, giving an R^2 value of 0.001.

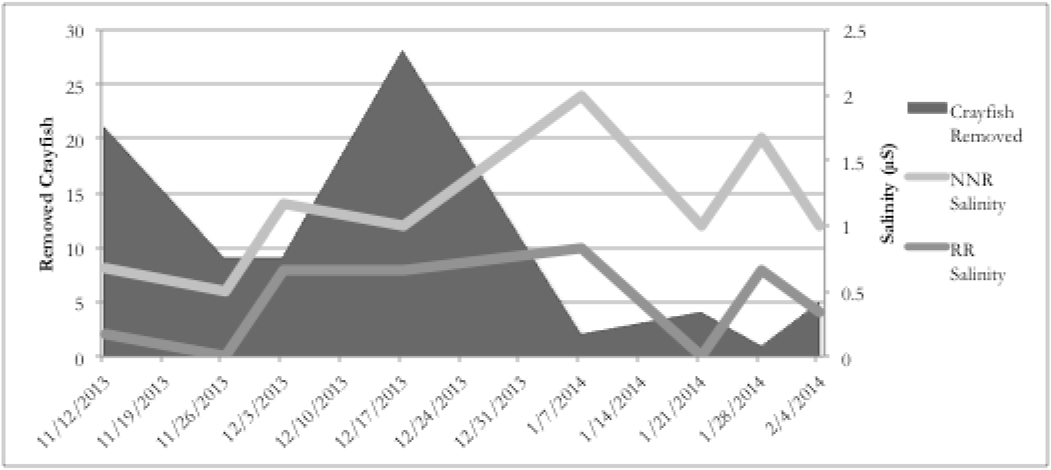


Figure 9-6 Salinity Levels and Numbers of Removed Crayfish.
(Note: This graph represents non-continuous data points.)

9.4.3 Benthic Macroinvertebrate (BMI) Sampling

The four BMI samples collected from the NRR in November 2013, December 2013, February 2014, and April 2014 contained a total of 676 individuals from four phyla, 14 orders, 35 families, and a total of 37 taxa. The samples collected from the RR contained a total of 3,195 individuals from three phyla, 14 orders, 37 families, and a total of 56 taxa (Appendix C). The three phyla represented in both samples were Arthropoda, Annelida, and Mollusca. In the NRR sample Nematoda were also present.

The most abundant taxa in the pooled NRR were Ostracoda (bean clams) with a relative abundance of 37.8%, Amphipoda (freshwater shrimp) with a relative abundance of 17.6%, and Physidae (pouch snails) with a relative abundance of 14%. In the pooled RR, the most abundant were Hydrobiidae (mud snails) with a 29.7% relative abundance, Amphipoda (freshwater shrimp) with a 26.1% relative abundance, and Chironomidae (non-biting midges) with a 15.3% relative abundance. The three most abundant orders comprise 69% of the NRR sample, and 71% or RR.

The five most abundant taxa for each event are depicted in Figure 9-7. This graph shows the transitions of the top five most abundant taxa during removal efforts from November 2013 - February 2014 and in April, two months after the efforts ended. Diversity of functional feeding groups (FFG) within the top five dominant taxa shifted from November - February. The removal reach maintained a higher diversity for most samples. Crayfish were the most abundant taxa for the NRR in November shifting to

Chironomidae in April. In contrast, the RR had a high abundance of Chironomidae in November, transitioned to Amphipoda and Hydrobiidae through February, and returned to Chironomidae in April.

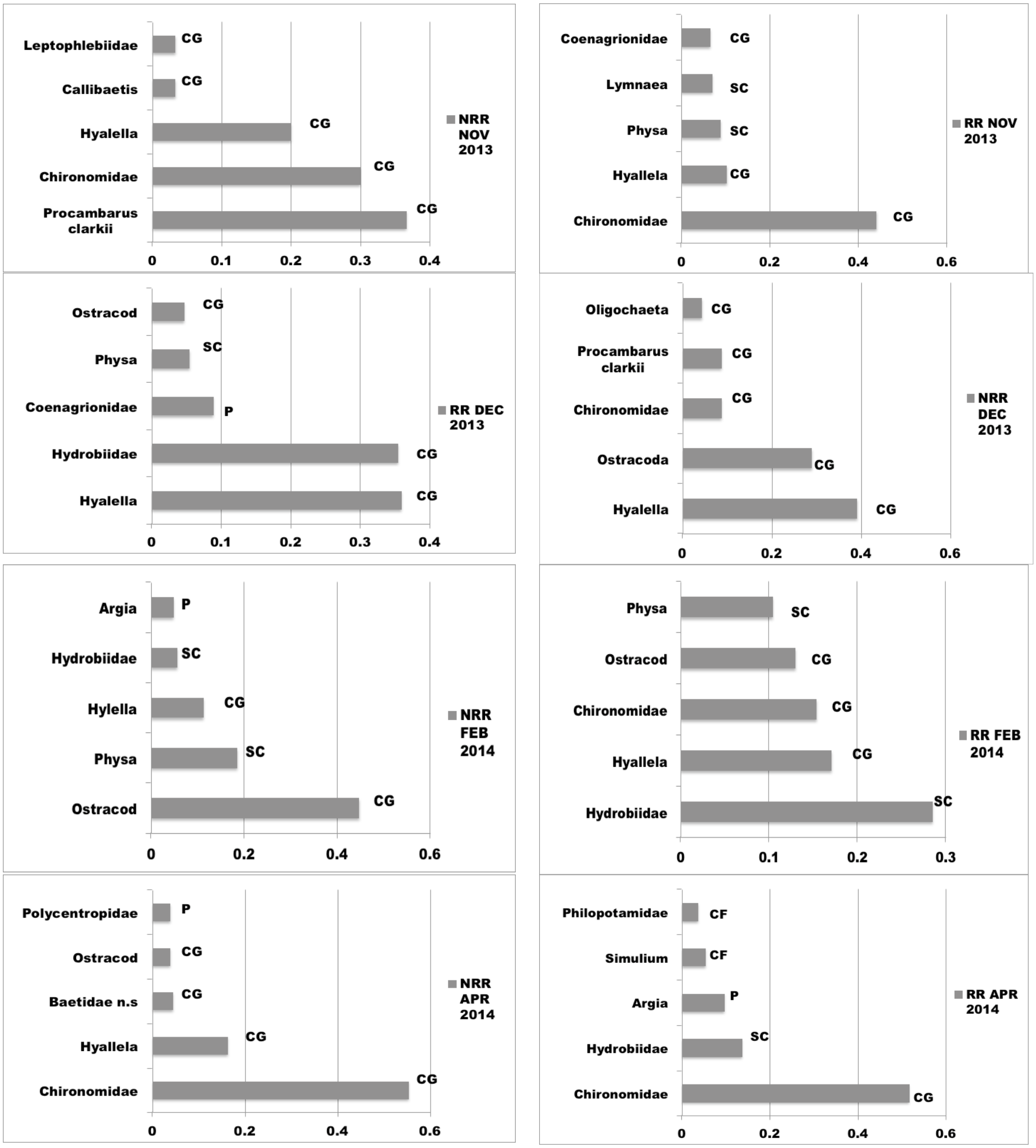


Figure 9-7 Comparison of BMI dominant taxa between the removal and non-removal reaches, Topanga Creek 2013-2014. Gastropoda were considered Scrapers; Simulium and *Philopotamidae* were considered Collector-Filterers; *Argia* were considered Predators; the rest were considered Collectors-Gatherers.

Table 9-1 shows the SCC-IBI metrics and scores of each BMI sample, with some additional metrics: the total number of individuals, total number of taxa, the dominant taxa, percent of dominant taxa, percent collector-gatherer, percent filterer-collector, percent scraper, percent predator, percent shredder, average tolerance value, number of Ephemeroptera taxa, number of Plecoptera taxa, number of Trichoptera taxa, percent of collector-gatherer plus filterer-collector, percent of non-insect, percent of tolerant taxa, number of Coleoptera taxa, number of predator taxa, percent of intolerant individuals, and the number of EPT taxa.

In both reaches, there was an increase in the BMI from November 2013 to April 2014. However, the BMI abundance in the NRR never reached 500 individuals. The BMI in the RR increased dramatically from 210 (November) to more than 1000 individuals (April). The percent dominant taxa remained high in both reaches.

The diversity of FFG also increased in both reaches over time. Collector-gatherers and predators were present throughout the samples, and scrapers, collector-filterers, and shredders started to appear respectively through February 2014 (see Table 9-1). The order of FFG dominance was as follows: collector-gatherer, scraper, predator, collector-filterer, and shredders. Shredders only appeared in the February 2014 RR sample when they had a higher dominance than collector-filterers. Once removal ceased, collector-gathers again increased to pre-removal levels.

The percent of EPT taxa tended to be higher in the RR, but evened out with the NRR after the removal efforts ended. There was no significant difference of percent tolerant, intolerant taxa, or average tolerance values between the RR and NRR reaches. Though the SCC-IBI metrics and scores were calculated for each sample, it is important to remember that none of the NRR samples and one RR sample did not meet the minimum 500 BMI abundance required by protocol. These samples are presented in Table 9-1 to provide a qualitative rather than quantitative comparison of the reaches over time.

To address the minimum abundance requirement, all BMI samples were pooled. The metrics and scores on Table 9-2 were then calculated from the pooled samples of each reach. The additional BMI metrics calculated in Table 9-1 were not calculated for this table. Using this analysis, both reaches fall within the fair range, with the removal site scoring slightly higher.

Figure 9-8 depicts the SCC-IBI metrics for each of the event samples and the pooled samples. This graph illustrates an increased percentage of intolerant and predator taxa between fall and spring. During active removal efforts, there is a large disparity between the two reaches from November through February; however by April (two months post removal), there was no significant differences observed.

Table 9-1 SCC-IBI Metrics and Scores for Removal and Non-Removal Reaches, Topanga Creek 2013-2014.

	NON-REMOVAL	REMOVAL	NON-REMOVAL	REMOVAL	NON-REMOVAL	REMOVAL	NON-REMOVAL	REMOVAL
ADDITIONAL IBI METRICS	11/20/13	11/20/13	12/6/13	12/5/13	2/20/14	2/20/14	4/24/14	4/24/14
Total # of Individuals	30	212	69	1263	227	1008	341	1171
Total # of Taxa	7	21	11	32	17	24	26	27
Dominant Taxa	P. clarkii	Chironomidae	Hyalella	Hyalella/ Hydrobiidae	Ostracod	Hydrobiidae	Chironomidae	Chironomidae
% Dominant	36.67	44.13	39.13	35 (each)	48.9	28.47	52.75	51.92
%CG	93.333	66.038	92.754	46.002	66.079	48.016	83.578	62.596
% FC	0	0.943	0	0.793	1.322	0.496	4.106	9.906
%SC	0	16.509	4.348	41.409	17.621	39.187	2.639	14.347
%P	3.333	11.321	1.449	11.164	11.894	7.044	7.331	11.699
% SH	0	0	0	0	0	1.984	0	0
Average Tolerance Value	7.700	6.690	7.731	8.228	7.760	7.406	6.471	7.940
Ephemeroptera Taxa	2	2	0	2	0	2	2	2
Plecoptera Taxa	0	0	0	0	0	1	0	0
Trichoptera Taxa	0	1	0	5	3	2	4	4
SCCIBI METRICS								
%CF+CG	93.333	66.981	92.754	46.714	67.401	48.512	87.683	72.502
% Non-Insect Taxa	42.857	38.095	54.545	28.125	47.059	33.333	23.077	29.629
% Tolerant Taxa	42.857	28.571	54.545	18.75	41.176	33.333	34.615	29.629
Coleoptera Taxa	0	2	1	4	0	1	2	2
Predator Taxa	1	6	1	10	6	9	9	8
% Intolerant Individuals	0	5.102	1.639	1.456	2.591	3.19	8.844	7.904
EPT Taxa	2	3	0	7	3	5	6	6
METRIC SCORES								
% CF+CG	1	8	1	10	8	10	3	6
% Non-Insect Taxa	1	8	0	5	0	4	6	4
% Tolerant Taxa	0	3	0	6	0	2	1	2
Coleoptera Taxa	0	4	2	7	0	2	4	4
Predator Taxa	0	3	0	7	3	6	6	5
% Intolerant Individuals	0	2	1	1	1	1	3	3
EPT Taxa	1	1	0	4	1	3	3	3
SUM (0-70)	3	24	4	40	13	28	26	27
ADJUSTED SCCIBI SCORE	4.3 (VERY POOR)	34.3 (POOR)	5.7 (POOR)	57.1 (FAIR)	8.6 (VERY POOR	40.0 (POOR)	37.1 (POOR)	38.6 (POOR)

Table 9-2 SCC-IBI Metrics and Scores for Pooled Samples, Topanga Creek 2013-2014.

	NON-REMOVAL	REMOVAL
ADDITIONAL IBI METRICS	**11/13-4/14**	**11/13-4/14**
Individuals (n)	***500***	***500***
SCCIBI METRICS		
%CF+CG	60.6	79
% Non-Insect Taxa	28.571	28.947
% Tolerant Taxa	25	34.211
Coleoptera Taxa	2	2
Predator Taxa	10	16
% Intolerant Individuals	5.797	3.692
EPT Taxa	6	8
METRIC SCORES		
% CF+CG	9	5
% Non-Insect Taxa	5	5
% Tolerant Taxa	4	1
Coleoptera Taxa	4	4
Predator Taxa	7	10
% Intolerant Individuals	2	2
EPT Taxa	3	4
SUM (0-70)	31	34
ADJUSTED SCCIBI SCORE	44.3 (FAIR)	48.6 (FAIR)

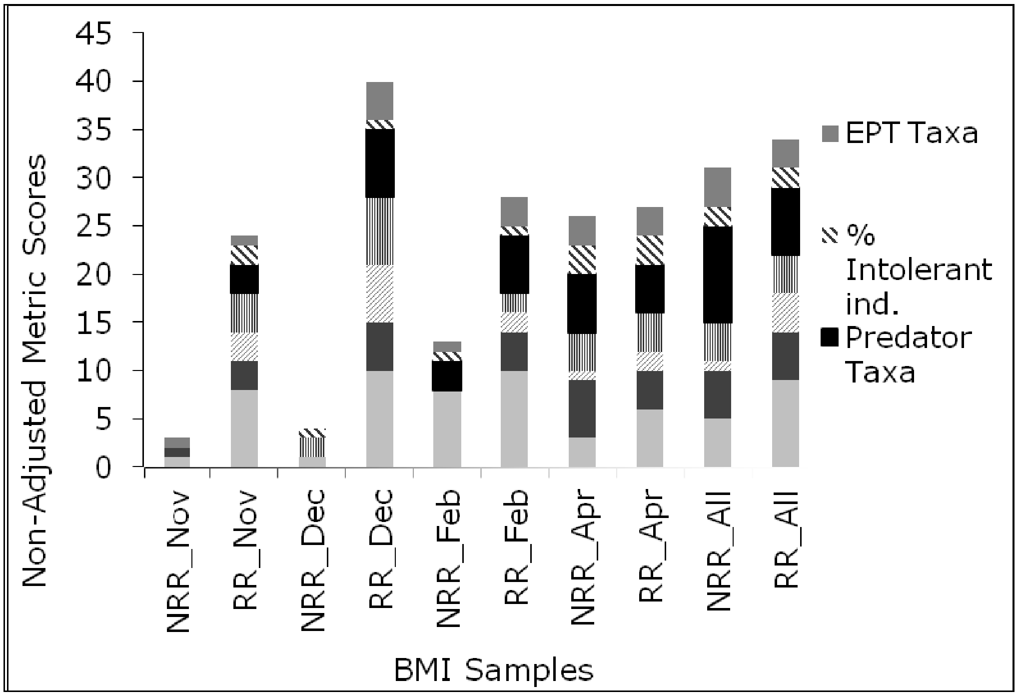


Figure 9-8 Breakdown of Non-Adjusted SCC-BMI Scores.
"All" represents the pooled samples.

Although all of the NRR samples and the November RR sample had BMI counts lower than 500, the SCC-IBI metrics were still calculated and used to describe changes over time. The individual event scores should not be ignored on the basis of low BMI numbers. It is true that the SCC-IBI metrics were not designed to deal with lower BMI counts, but the metrics do provide an idea of the relative state of the BMI community. The species richness, the percentage of each FFG, dominant taxa, and total abundance were also IBI indicators of BMI community health that were taken into account. When samples for each reach were pooled to get an overall status of the BMI community that adhered to the required statistics for the SCC-IBI metrics, the RR's BMI community appeared to be in a better condition than the NRR.

The SCC-IBI scores give a wider context to the overall condition of Topanga Creek when compared to other creeks in southern California. Topanga Creek would not be considered a reference creek based solely on the SCC-IBI score. The scores of the samples containing at least 500 BMI, consistently put the creek in the "Poor" to "Fair" range and the pooled scores have a range of "Fair." The reaches scores fall among the lowest in the Santa Monica Mountains. When compared to Heal the Bay's 2013 SCC-IBI scores for Arroyo Sequit Creek, Solstice Creek, Cold Creek, and Malibu Creek, the Topanga Creek crayfish pooled scores ranked second lowest, with Malibu Creek having the worst scores.

Using historic data from Topanga Creek collected during snorkel and other visual surveys (2001-2014), crayfish presence was compared to the presence of amphibians, and crayfish found in *O. mykiss* stomach contents (Krug et al. 2012). There was no evidence to suggest that crayfish impacted the presence of California tree frogs or the pacific tree frogs as observations of those species remained consistent over time. However, there was a distinct negative correlation between crayfish presence and California Newts (RCDSMM *unpublished data*). Local researchers have observed crayfish eating newts (Kats et al. 2013; RCDSMM *unpublished data*). Since the crayfish population explosion in 2011 in Topanga Creek, there has also been an increased incidence of crayfish found within large (10 inches and up) rainbow trout's diet (Krug et al. 2012). The increased number of crayfish appears to have changed the BMI community for the worse and they appear to have also impacted the newt population, (Figure 9-9). To make circumstances worse, the drought that has plagued southern California for the last few years has only been increasing the preferred habitat for crayfish and worsening habitat conditions for native wildlife.

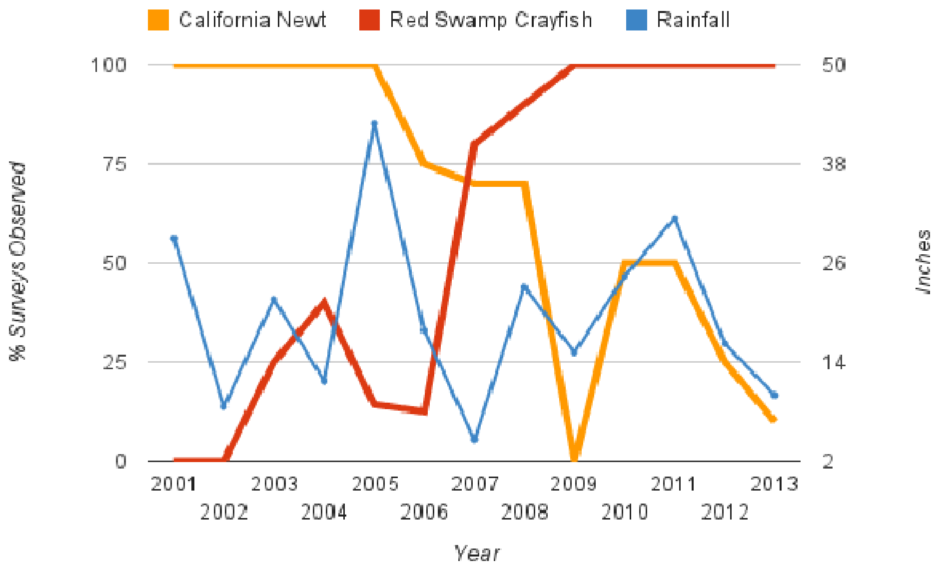


Figure 9-9 Observations of Crayfish and CA Newts compared to Water Temperature in Topanga Creek 2001-2014.

Sustained crayfish removal efforts produced positive results in the BMI community and volunteer actions, through citizen science efforts, can promote a wide public involvement in active restoration efforts. In just a few months of removal, the BMI community improved into the "fair" SCC-IBI range. In the future, more study reaches and BMI collection sites should be established to provide more in-depth comparisons. While it is not feasible to conduct removal throughout the entire creek, the results of this study suggest that a focused removal effort following strong winter storm pulses that reduce the population throughout the creek could be beneficial.

9.5 Summary

- Crayfish removal had no effect on water quality or nutrient levels.
- Crayfish removal improved BMI community compositions while on-going but the effect was not observed two months after removal ceased.
- Crayfish removal could be beneficial in improving ecosystem health and nutrient cycling within the creek.

9.6 Acknowledgements

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10 Benthic Algae in Topanga and Malibu Creeks

10.1 Abstract

Water quality monitoring has historically relied on chemical parameters but recent work has recognized that integrating biological responses to water quality changes can provide a more complete understanding of ecosystem sensitivity, resiliency and status. Periphyton are found in all aquatic environments and can tolerate a wide range of nutrient levels and overall water quality (Hoffman 1994). Monitoring benthic algae is becoming more common as tools are developed to allow for a better understanding of the relationship and response of these sensitive organisms to the aquatic environment. Topanga and Malibu Creeks represent the second and third largest watersheds within the Santa Monica Mountains and support a variety of special status aquatic species. Comparison of the benthic algae community conditions in 2013 utilizing both standard metrics (Rhithron Associates, Inc. 2014) and relatively new southern California Index of Biotic Integrity (Fetscher et al. 2014) indices suggests that although Malibu Creek is listed as impaired for nutrients, sediment and trash, the more consistent flow regime provided by summer flow augmentation supports a spring benthic algal community that is not substantively different from that found in Topanga Creek, which is not listed for any impairments and has no summer flow augmentation. This suggests that a complex, synergistic pattern of abiotic and biotic variables are shaping the biological integrity of these creeks. It is hoped that the use of both diatoms and soft-body algae as diagnostic tools to provide secondary indicators and multiple lines of evidence will better characterize the responses of southern California creeks to both natural events (floods, wildfire) and anthropogenic inputs providing a more complete picture of stream health in these systems. That being the case, some of the common diatom indicator species with fairly well described Total Nitrogen (TN) preferences, both high and low, were found in both Topanga and Malibu, which provides a somewhat confusing result. This could possibly be a result of inability to differentiate between species in the same genus that appear taxonomically similar, but in fact represent different species with different tolerance preferences. It could also mean that further refinement of the tolerance limits and preferences is needed. This study provides a snapshot of baseline conditions for future comparison.

10.2 Introduction

Periphyton abundance and diversity, specifically diatom and soft-bodied algae species, are a potentially useful indicator of water quality and are often used in California and elsewhere in conjunction with water quality and benthic macroinvertebrate monitoring (Fetscher et al. 2009, Fetscher et al. 2014). Benthic algae (both diatoms and non-diatoms) are a primary energy source in stream food webs (Stevenson 1996) and an important component of periphyton. This variable of water quality testing is relatively new to the regulatory testing framework, but a well-established national database of diatoms suggests that much can be learned by identifying species presence and abundance (Potapova and Charles 2003, Potapova 2005, Potapova and Charles 2007). In order to function as a useful water quality indicator, a species needs to have a narrow range of ecological tolerances, a wide distribution range and be relatively commonly observed. Following the framework promoted by Potapova (2005), we have documented the abundance and distribution of diatom and non-diatom species found in Topanga Creek and then examined the habitat and water quality characteristics associated with their presence to begin developing an ecological profile of southern California taxon. Recent work in Malibu Creek supports this concept and data collection is in progress to further investigate diatom community structure and distribution relative to variables such as conductivity (Orton 2012).

Diatoms (phylum Bacillariophyta) are single celled algae that come in a variety of shapes, although primarily centric (round) or pennate (elongate). They are characterized by a silicon based shell called a frustule, that has two halves that fit tightly together, but have pores that allow for nutrient movement into the cell, and wastes to pass out of the cell. They are particularly sensitive to changes in dissolved oxygen, pH, nitrogen and especially conductivity. One of the benefits of using diatoms as water quality indicators is that they respond quickly (within hours to days) to changes in the environment such as variation in pH or water temperature by modifying their exoskeleton shape (Prygiel and Coste 2000).

Soft-body algae include a variety of taxa that are widely distributed, colonize almost every stream substrate, reproduce quickly and respond rapidly to changes in the environment; thus, they are useful not only as a way of detecting impairments, but also can assist in diagnosing impairment causes (Fetscher et al. 2009). Recent advances in the development of algae-based Indices of Biotic Integrity (IBI) suggest that in southern California streams, these non-diatom species provide additional insight into water quality conditions (Fetscher et al. 2014).

In addition to documenting the diversity of the diatom and soft-bodied algal communities, chlorophyll a and ash free dry mass (AFDM) are used to estimate the relative amount of algal biomass, which is a proxy for estimating stream productivity. Chlorophyll a is a specific form of chlorophyll present in algal cells that is critical for photosynthesis. The concentration of chlorophyll a varies with depth, water temperature, and season, and provides a way of quantifying the amount of active photosynthesis at the time of sampling. Ash free dry mass is the difference between the wet and post combustion weight of the sample, providing a complimentary way of quantifying algal biomass (Fetscher et al. 2009). These measurements can assist in developing an autotrophic index, which is the ratio of ash free dry mass to chlorophyll a that can reflect response to nutrient enrichment (index value increases) and biological oxygen demand fluctuation (Biggs 1989).

It is hoped that the use of both diatoms and soft-bodied algae as diagnostic tools will provide secondary indicators and multiple lines of evidence to better characterize the responses of southern California creeks to both natural (floods, wildfire) and anthropogenic inputs. This will enhance analysis of these metrics within two major creeks in the Santa Monica Bay. By including these additional metrics to the water quality assessment effort, we hope to assist in developing regional ambient and exceedance level data.

10.3 Methods

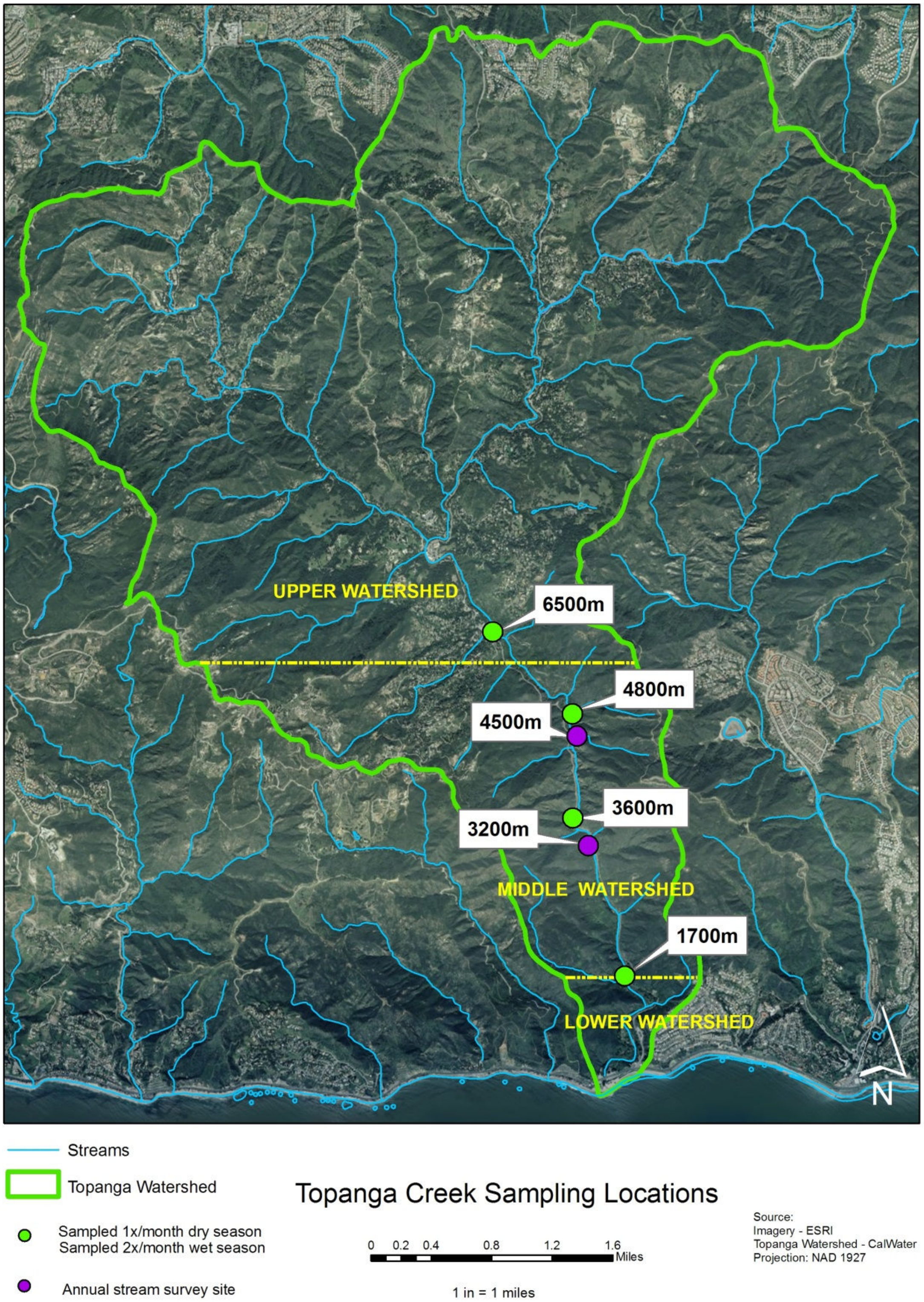
Sample Sites

Topanga Creek is the third largest drainage into the Santa Monica Bay and over 70% of the watershed is public open space wildlands within Topanga State Park.

Samples were collected in the main stem (stream order 2) 4,662 hectare Topanga Creek during stream surveys on 30 April 2013, 6 May 2014 in the upper reach approximately 4500-4650 m upstream of the ocean, and on 2 May 2013, 5 May 2014 in the lower reach located approximately 3200-3350 m from the ocean, concurrently with physical habitat condition (Fetscher et al. 2009), and in-situ water quality (temperature, dissolved oxygen, pH, conductivity) (Figure 10-1). At the same time, grab samples for fecal indicator bacteria (total coliform, *E. coli* and enterococcus), nutrients (nitrate-N, nitrite- N, ammonia – N, orthophosphate) and turbidity were collected, put on ice and analyzed within six hours. Benthic macroinvertebrate samples were collected in the same reaches, along with presence and abundance of amphibians and fish.

These 150 meter reaches were initially selected to represent portions of the main stem of Topanga Creek below town. Since 2001 steelhead trout have been present in the lower gradient portion (3200-3350 m, average gradient <3%); and since 2005 in the higher gradient reaches from 4500-4650 m (average gradient 3-6%). Additionally, the lower gradient reach (3200-3350 m) is adjacent to Topanga Canyon Boulevard, and subject to higher level of anthropogenic disturbance than the higher gradient reach (4500-4650 m), which is deeper in the canyon, away from the road and while subject to some disturbance, is much less accessible than the lower reach.

Diatom and soft-bodied algae data was also available for Malibu Creek in 2013. The Malibu Creek Watershed is the second largest system draining into the Santa Monica Bay at 28,231 hectares. Samples were collected on 24 April 2013 at two locations (R-3 and R-4, Figure 10-2) in lower Malibu Creek (stream order 4) below Rindge Dam. Physical habitat, water quality documentation, and benthic macroinvertebrate sampling as per Ode (2007) and Fetscher et al. (2009) protocols were also collected.



Source:
Imagery - ESRI
Topanga Watershed - CalWater
Projection: NAD 1927

Figure 10-1 Map of Topanga Creek Sampling Locations as distance measured from the ocean 2013-2014.

Source:
Imagery - ESRI
Sampling Locations - LVMWD & RCDSMM
Projection: NAD 1983 Albers

Figure 10-2 Map of Malibu Creek Sampling Locations 2013. R3 and R4 are sampling locations for the Las Virgenes Municipal Water District. Start Pool is the location of a data sonde.

Sample Collection

Stream algae and diatom samples were collected with assistance from biologists at Aquatic Bioassay and Consulting Laboratories, Ventura, CA. Methods followed the sampling protocols identified by Surface Water Ambient Monitoring Protocol (Fetscher and McLaughlan 2008, Fetscher et al. 2009). This method established 11 transects in a 150 meter stream reach. Samples were collected from substrate present at each transect (alternating right side, center and left side of wetted width) located 1 meter downstream from the transect and combined into a single composite sample. Collection methods varied according to substrate and habitat type according to the protocol. An ABS delimiter (plastic coring device) was used to collect loose substrate up to 1 cm deep in a depositional habitat with fine gravel, sand or silt substrate. A metal spatula was placed underneath the delimiter to ensure collection of any loose material. A rubber delimiter was used to isolate a 12.6 cm^2 area of algae when wrapped around cobble or other erosional and removable object. A toothbrush was used to scrub the algae from the surface. For immovable substrate (i.e. boulders, bedrock or concrete), a syringe scrubber was used to collect algae from underwater. The plunger was retracted and the scrubber was removed and rinsed into a wash bucket.

Upon collection of all 11 subsamples, field processing was done according to three protocols. A 25 ml composite sample was filtered through glass fiber pre-filters using a hand pump. The filter was placed into a petri dish, covered in aluminum foil and placed on dry ice until analyzed in order to determine ash free dry mass and chlorophyll a. Diatom samples were prepared by combining 10 ml formalin preservative with a 40 ml of composite sample water in a 50 ml centrifuge tube, covered in foil and placed on wet ice. Soft-bodied algae was mixed with 5ml of glutaraldehyde solution with 45 ml of the composite sample water in a 50 ml centrifuge tube covered in foil and stored on wet ice.

Sierra Environmental (Reno, NV) did the analysis of Ash Free Dry Mass (SM 2540) and Chlorophyll a (SM 10200). Diatom and soft-bodied algae samples were identified and enumerated by Academy of Sciences, Philadelphia, PA in 2013 and by Rhithron Associates, Inc (Missoula, MT) in 2014.

Index of Biotic Integrity Analysis

Recent work has evaluated a variety of possible stream indices using diatom and non-diatom soft-bodied algae to compare biotic integrity, providing more reliable comparisons between sites both spatially and temporally. Using an online calculator provided by SCCWRP to calculate the southern California Diatom and non-diatom species IBI described by Fetscher et al. (2014), data from two sites located in Topanga and Malibu Creeks were compared. Unfortunately data on benthic macroalgae for Malibu Creek was only available for 2013 at this time.

Diatoms Metrics

Metrics used to describe and quantify the diatom community in relation to stream water quality have been selected to examine the response of diatoms to impairments. The multi-metric analysis contains five subsets that are designed to quantify various components of diversity as compiled by Rhithron Associates, Inc (Table 10-1).

Species richness, diversity and dominant taxon of the diatom species collected reflects the community structure at each site. Species richness and Shannon diversity values decrease with increasing water quality impairments. Dominance values increase with increasing water quality impairments.

Sediment metrics characterize species found in unstable habitats (Barbour et al. 1999). Diatoms are designated as highly motile, moderately motile, not motile and having variable motility. The percentage of highly motile species that are able to hold their position on the substrate surface increases with increased sedimentation (Lange-Bertalot 1979). Some species in the genus *Navicula*, *Nitzschia* and *Surirella* are associated with increases in siltation and sedimentation. However, *Nitzschia palea* has been identified as an oligotraphentic low –nutrient indicator (Potopova and Charles 2007) and was only observed in Topanga Creek.

Organic nutrient measures include several metrics related to organic pollution tolerance. Species are rated as 1(most tolerant to organic pollution) to 3 (sensitive to organic pollution) (Van Dam et al. 1994). To obtain the pollution tolerance index, the species tolerance value is multiplied by its abundance, and then that value is divided by the total abundance for the site. A low pollution index score indicates poor water quality (Van Dam et al. 1994).

Halophytic algae have wide osmoregulation ranges/tolerances but also increase with increased nutrients and suspended sediment levels. Eutrophic water often have higher pH levels.

Other metrics for pollution include the percent relative abundance of facultative and obligate nitrogen heterotrophs based on their nitrogen (N) uptake. The percentage of heterotrophic taxa increases with decreased water quality thus the relative abundance of nitrogen hetrotrophs can be used as an indicator of organic nitrogen compounds and/or reduced light available (Van Landignam 1982, Porter 2008). For example, *Rhopalodiales* species fix nitrogen and are extremely responsive to nutrient loading because they are less competitive in a eutrophic environment.

The diatom values are:
1. Nitrogen autotroph tolerates very small concentration of organic nitrogen
2. Nitrogen autotroph tolerates elevated concentration of organic nitrogen
3. Facultative nitrogen heterotroph need periodically elevated levels of organic nitrogen
4. Obligate nitrogen heterotroph need continuously elevated levels of organic nitrogen

Polysaprobous species thrive in waters rich in decomposing organic material and having greater than 10% oxygen (Van Dam et al. 1994). Values assigned to diatom taxa are as follows:
1. Oligosaprobous (intolerant to organic pollution)
2. Beta – mesosaprobous
3. Alpha – mesosaprobous
4. Alpha-meso/polysaprobous
5. Polysaprobous (organic pollution tolerant species)

Low Dissolved Oxygen (DO) Taxa are diatom species that are tolerant of very low, to low dissolved oxygen levels (below 10% saturation, assigned a value of 5). High Dissolved Oxygen Taxa are those that require ~100% saturation continuously. As the levels of dissolved oxygen available decreases, the percentage of these tolerant taxa increases,.

Inorganic nutrients metrics compares the level of nutrient autotrophism based on the relative abundance of nitrogen autotrophs that tolerate small concentration of organic N to those that tolerate higher concentration of organic N. As water quality degrades, the percent abundance of nitrogen autotrophs decreases. The other metric included here compares the percent relative abundance of eutraphentic (preferring high nutrient levels) and hypereutraphentic diatom taxa.

Metals tolerant taxa, abnormal cells and percent disturbance taxa can be indicators of elevated concentrations of heavy metals. The presence of the cosmopolitan species *Achnanthidium minutissimum* is an indication of disturbance related to a recent scour event or some type of toxic organic pollution input. However, in southern California, *A. minutissimum* is also associated with clean water (Dr. Fetscher, *personal communication*).

Table 10-1 Definitions of Metrics.
Aquatic Bioassay and Consulting Laboratories (2014)

Metric Group	Definition	Reference
Pollution Tolerance Class	Tolerance to organic pollution according to Lange-Bertalot 1979; 1=most tolerant of pollution; 2=tolerant of pollution; 3=sensitive to pollution	Lange-Bertalot 1979
Habitat	A = aerophile; P = planktonic	
pH	1 acidobiontic, optimum pH <5.5; 2 acidophilous, pH <7; 3 circumneutral, pH ~7; 4 alkaliphilous, mainly pH >7; 5 alkalibiontic, exclusively pH >7; 6 indifferent, no apparent optimum	
Salinity	1 fresh; 2 fresh brackish; 3 brackish fresh; 4 brackish; 5 marine (see Van Dam et al. 1994 for criteria)	Van Dam et al. 1994
Nitrogen Uptake Metabolism	1 nitrogen autotroph tolerating very small concentrations of organic nitrogen; 2 nitrogen autotroph tolerating elevated concentrations of organic nitrogen; 3 facultative nitrogen heterotroph; 4 obligate nitrogen heterotroph	
Oxygen Requirements	1 continuously high (~100% saturation); 2 high (>75%); 3 moderate (>50%); 4 low (>30%); 5 very low (~10% saturation)	Van Dam et al. 1994
Saprobity	Amount of organic matter decomposing: 1 oligosaprobous (poor); 2 beta-mesosaprobous; 3 alpha-mesosaprobous; 4 alpha-meso-/polysaprobous; 5 polysaprobous (rich) (see Van Dam et al. 1994 for criteria)	Van Dam et al. 1994
Trophic State	1 oligotraphentic; 2 oligo-mesotraphentic; 3 mesotraphentic; 4 meso-eutraphentic; 5 eutraphentic; 6 hypereutraphentic; 7 oligo- to eutraphentic (variable); 8 dystrophic	Van Dam et al. 1994
Moisture	1 rarely occurs outside water bodies; 2 mainly in water but sometimes on wet places; 3 mainly in water but regularly on wet or moist places; 4 mainly on wet, moist, or temporarily dry places; 5 occurs almost exclusively outside water bodies	
Motility	H = highly motile; M = moderately motile (diatoms with raphes but not highly motile); N = not motile; V = variable motility (source: Jan Stevenson)	Jan Stevenson, This one is not really well documented, but see: Bahls 1993 and Barbour et al. 1999
Distribution	N = North American endemics; C = cosmopolitan in temperate regions, broad ecological niche, generally aggressive and opportunistic species that develop large populations in response to disturbance and may exclude native species	Lange-Bertalot 1996

10.4 Results

10.4.1 Diatoms

Table 10-2 compares the metrics from each location in Topanga Creek in 2013 and 2014. A total of 125 diatom species were observed in Topanga Creek in 2013-2014. A total of 46 species, many of them of cosmopolitan distribution, were common to both years, with 40 different species found only in 2013 and 39 species found only in 2014. As shown in Table 10-2, the majority of metrics remained similar, with the exception of a decrease in motile taxa present in 2014 at both sites, a decrease in low DO taxa present at both sites in 2014, and a decrease in percent Rhopalodiales in 2014. Percent of sediment tolerant taxa increased slightly in both locations.

The percent dominant taxa increased slightly in the lower reach, but more in the upper reach. In 2013, the 4500 m higher gradient reach had only 23 species unique to that section, as compared to 26 species unique to the 3200 m lower gradient reach. In 2014, the species unique to each site declined in both the upper reach (18 species) and lower reach (23 species).

The percentage of pollution tolerant taxa increased in the lower reach in 2014, while it decreased in the upper reach. While these differences could be due to sampling error or patchy distribution, it could also suggest that conditions in the creek are changing, even though the pollution index values are not significantly different from year to year or even between sites.

The percentage of species tolerating nutrient enriched waters is slightly higher in the lower gradient reach as compared to in the upper gradient reach.

Table 10-2 Metrics for Diatoms in Topanga Creek Spring 2013 and 2014.

Group	Metric	TC4500-4500m 2014	TC4500-4500m 2013	TC3200-3350m 2014	TC3200-3350m 2013
	COMMUNITY STRUCTURE				
Diversity	Shannon H (log2)	4.44	4.87	4.72	4.73
Diversity	Species Richness	62	61	66	64
Dominance	Dominant Taxon Percent	27.33	16.17	17.17	16.00
	SEDIMENT				
Siltation	Siltation Taxa Percent	36.17	35.00	36.83	35.67
Motility	Motile Taxa Percent	53.67	59.67	55.83	59.17
	ORGANIC NUTRIENTS				
Oxidation	Low DO Taxa Percent	7.17	8.50	8.17	9.83
Pollution	Pollution Index	2.52	2.58	2.43	2.56
Rhopalodiales	Rhopalodiales Percent	2.00	3.67	2.00	3.17
Saprobity	Polysaprobous Taxa Percent	22.33	26.33	32.00	29.33
Heterotrophism	Nitrogen Heterotroph Taxa Percent	11.67	10.17	17.00	14.67
	INORGANIC NUTRIENTS				
Autotrophism	Nitrogen Autotroph Taxa Percent	75.00	70.67	70.33	73.67
Trophic State	Eutraphentic Taxa Percent	45.83	47.33	55.50	75.50
	METALS				
Disturbance	Disturbance Taxa Percent	0.00	0.00	0.33	0.00
Metals Tolerance	Metals Tolerant Taxa Percent	3.00	1.83	4.00	2.83
Abnormality	Abnormal Cells Percent	0.00	0.00	0.00	0.00
Acid Tolerance	Acidophilous Taxa present	0.00	NR	0.17	NR

*Compiled by Rhithron Associates Inc. *NR = not recorded

10.4.2 Soft-bodied Algae in Topanga Creek

The samples collected during the annual spring stream survey were complemented by both qualitative and quantitative algae data from monthly sampling at six sites throughout Topanga Creek between December 2012 and August 2014. The dominant algal species observed throughout the creek were *Cladophora sp.* and *Ulva sp.* Percent cover at transects was low throughout (<20% at all sites) with a seasonal increase in summer (graphs are found in Appendix A).

In 2013, the dominant species of algae observed in both study reaches in Topanga Creek was *Cladophora glomerata*. The loss of all epiphytes as well as *Cladophora* in the lower reach in 2014 documents a major shift of the algal community between years. This could be a result of the drought condition in the creek during the winter of 2013-2014.

Only four algal taxa were common to both locations in 2013. *Heteroleibleinia*, a filamentous cyanobacteria, was the only species common to both sites in 2014 (Table 10-3). The upper gradient reach had a total of 10 taxa represented, while the lower gradient reach had 13 taxa (Table 10-4). In 2014, no epiphytes, macroalgae, or quantitative algae samples were collected, and the number of species in the upper reach increased to 25 species, while the diversity at the lower reach decreased to eight.

Most of these species are widespread and tolerate a wide variety of water quality conditions, but the 22 species of cyanobacteria are mostly indicative of a low nitrogen environment. *Phormidium sp* found only in 2013 are considered indicative of a medium level of pollution (Potapova 2005).

Table 10-3 Qualitative Presence/Absence of Soft-body Algae species, Topanga Creek Spring 2013 and 2014.

Phylum	Class	Species	TC4500 2014	TC4500 2013	TC3200 2014	TC3200 2013
Chlorophyta	Ulvophyceae	*Cladophora glomerata*		P		P
Cyanobacteria	Cyanophyceae	*Oscillatoria sp 1*				P
Streptophyta	Zygnematophyceae	*Mougeotia sp 1*				P
		Spirogyra sp 1				P

Table 10-4 Quantitative Soft-body Algae Abundance in Topanga Creek Spring 2013 and 2014.

Algae Type	Phylum	Class	Species	Unit	TC4500 2013	TC4500 2014	TC3200 2013	TC3200 2014
Epiphyte	Chlorophyta	Chlorophyceae	*Characium pringsheimii*	Count	27		12	
			Oedogonium sp 1	Count			1	
	Cyanobacteria	Cyanophyceae	*Xenococcus sp 1*	Count			5	
			Heteroleibleinia	Count	78		84	
Macroalgae	Chlorophyta	Ulvophyceae	*Cladophora glomerata*	um3/cm2	7,633,247,643		1,628,106,255	
Microalgae	Chlorophyta	Xanthophyceae	*Ophiocytium sp*	um3/cm2		4,829		
			Chlorophyta 1	um3/cm2		121,078		
			Chlorophyta 5	um3/cm2		765,164		
			Chlorophyta 6	um3/cm2		93,337		
			Chlorophyta 7	um3/cm2		7,730,896		
			Chlorophyta 8	um3/cm2		41,791		
			Chlorophyta 9	um3/cm2				40,656
		Chlorophyceae	*Desmodesmus communis*	um3/cm2		5,363		
			Microspora sp	um3/cm2				112,293
			Oedogonium sp 1	um3/cm2	12,189,982	6,337,349		
			Scenedesmus circumfusus	um3/cm2		797		
			Scenedesmus communis	um3/cm2			24,186	
			Scenedesmus dispar	um3/cm2			5,296	
			Scenedsmus sp	um3/cm2				500
			Scenedsmus sp 1	um3/cm2		414		
			Stigeoclonium sp	um3/cm2		427,438		
		Ulvophyceae	*Cladophora glomerata*	um3/cm2	16,814,197,379	72,894,953		
	Cyanobacteria	Cyanophyceae	*Calothrix sp 2*	um3/cm2		143,579		
			Calothrix sp 3	um3/cm2		852,874		
			Cyanophyceae 5	um3/cm2	11,352			
			Heteroleibleinia	um3/cm2	306,900	14,231		5,479

Algae Type	Phylum	Class	Species	Unit	TC4500 2013	TC4500 2014	TC3200 2013	TC3200 2014
			Homoeothrix janthina	um3/cm2			215,030	
			Komvophoron	um3/cm2	157,910			
			Leibleinia sp			2,560		
			Leptolyngbya	um3/cm2			4,502,054	52
			Leptolyngbya sp 1	um3/cm2		2,131		
			Nostocales 1	um3/cm2				12,021
			Oscillatoria limosa	um3/cm2			14,191,066	
			Oscillatoriales1	um3/cm2		196,631		
			Oscillatoriales 2	um3/cm2		51,330		
			Oscillatoriales 3	um3/cm2		347,358		
			Oscillatoriales 4	um3/cm2		66,602		
			Oscillatoriales 5	um3/cm2		9,902		
			Oscillatoriales 6	um3/cm2		735		2,565
			Oscillatoriales 7	um3/cm2		5,134		
			Oscillatoriales 8	um3/cm2				80,370
			Phormidium sp 1	um3/cm2	3,454,135		2,222,162	
			Phormidium sp 2	um3/cm2			152,622	
			Pseudanabaena sp	um3/cm2		589		
		Euglenophyceae	*Heteronema sp*	um3/cm2		89,747		
			Phacus sp	um3/cm2				360,503
	Heterokonto-phyta	Xanthophyceae	*Ophiocytium sp*	um3/cm2		24,739		
	Rhodophyta	Florideophyceae	*Chantransia sp 1*	um3/cm2		93,865	2,855,514	
	Streptophyta	Zygnematophyceae	*Mougeotia sp*	um3/cm2				560,633
	Streptophyta	Zygnematophyceae	*Mougeotia sp 1*	um3/cm2	1,806,947,786	5,528,034		
			Spirogyra sp	um3/cm2				22,241,851

10.4.3 Comparison of benthic algae in Topanga and Malibu Creeks 2013

In addition to collecting samples in Topanga, biologists from Aquatic Bioassay Consulting Inc. assisted the Las Virgenes Municipal Water District (LVMWD) in collecting samples from Malibu Creek using the same protocol and analysis as used in Topanga (Aquatic Bioassay 2014).

Topanga sites had a higher diatom species richness and diversity as compared to Malibu sites, with 26 species common to both creeks (Table 10-5). Several species, including *Encynoma silesiacum, Pseudostaurosira brevistriata, Nitzschia liebethruthii,* and *Gomphonema parvulum* are only found at R4 in Malibu. Although there is high variability in species richness and diversity information associated with the patchy nature of distribution and sampling biases/errors, 60 species is a typical mean number of species collected in southern California (Dr. E. Fetscher *pers. communication*).

The total number of diatom species observed in the two lower Malibu Creek sites (both located downstream of Rindge Dam), exhibited less overall community diversity by all metrics. The site adjacent to anthropogenic inputs (R4) had a higher species richness than the less disturbed location approximately 400 meters upstream in Malibu Creek State Park (R3) (Aquatic Bioassay Consulting Inc. 2014).

Table 10-5 Metrics Comparing Diatoms in Topanga and Malibu Creeks Spring 2013.

Group	Metric	TC4500m 2013	TC3200m 2013	Malibu R-4 2013	Malibu R-3 2013
	COMMUNITY STRUCTURE				
Diversity	Shannon H (log2)	4.8672	4.7337	3.8	2.97
Diversity	Species Richness	61	64	34	20
Dominance	Dominant Taxon Percent	0.1617	0.1600	0.23	0.28
	SEDIMENT				
Siltation	Siltation Taxa Percent	0.3500	0.3567	0.29	0.6
Motility	Motile Taxa Percent	0.5967	0.5917	0.37	0.12
	ORGANIC NUTRIENTS				
Oxidation	Low DO Taxa Percent	0.0850	0.0983	0.04	0.01
Pollution	Pollution Index	2.5817	2.5567	2.62	2.87
Rhopalodiales	Rhopalodiales Percent	0.0367	0.0317	0.00	0.00
Saprobity	Polysaprobous Taxa Percent	0.2633	0.2933	0.28	0.11
Heterotrophism	Nitrogen Heterotroph Taxa Percent	0.1017	0.1467	0.28	0.06
	INORGANIC NUTRIENTS				
Autotrophism	Nitrogen Autotroph Taxa Percent	0.7067	0.7367	0.67	0.90
Trophic State	Eutraphentic Taxa Percent	0.4733	0.7550	0.49	0.88
	METALS				
Disturbance	Disturbance Taxa Percent	0.0000	0.0000	0	0.00
Metals Tolerance	Metals Tolerant Taxa Percent	0.0183	0.0283	0.02	0.01
Abnormality	Abnormal Cells Percent	0.0000	0.0000	0.00	0.00

All of the most abundant diatom species (Table 10-6) except *Nitzschia* are considered to be sensitive to pollution, suggesting that water quality conditions overall are within their tolerance limits. Additionally, most are non-motile species and require high levels of dissolved oxygen, but can tolerate elevated concentrations of nitrogen. *Nitzschia* is a very rich genus with several hundred species and wide tolerance ranges and is usually associated with brackish and organically polluted water with high nutrients and low dissolved oxygen (Van Dam et al. 1994).

Table 10-6 Most abundant species in both Topanga and Malibu Creeks 2013-2014.

Species	TC4500m 2014 count	TC3200m 2014 count	TC 4500m 2013 count	TC3200m 2013 count	Malibu R-4 2013 count	Malibu R-3 2013 count	Pollution Tolerance Level
Amphora inariensis	4	0	26	58	20	11	3
Amphora pediculus	78	71	61	35	19	28	3
Cocconeis pediculus	5	1	22	14	11	170	3
Cocconeis placentula	12	11	19	6	7	131	3
Cocconeis placentula var lineata	32	50	96	27	177	125	3
Nitzschia inconspicua	31	58	49	41	100	29	2
Planothidium frequentissimum	20	37	12	11	0	0	NA
Rhoicosphenia abbreviata	0	17	24	10	47	19	3
Staurosira construens var venter	164	103	33	97	139	26	3

Organic Pollution tolerance: 1= most tolerant, 2= tolerant, 3= sensitive to organic pollution
NA = not available

Using a one-tailed t-test to compare the diatom communities between the two samples and sites, the Shannon H diversity measure was significantly higher ($p<0.05$) in Topanga than Malibu. Motile taxa are more significantly abundant ($p<0.05$) in Topanga than in Malibu, as are the percentage of Rhopalodiales ($p< 0.05$). However, comparison of the pollution tolerant index shows that Malibu has significantly higher ($p< 0.05$) levels of pollution tolerant taxa than Topanga. The only other significant result was that dissolved oxygen levels were lower in Topanga ($p< 0.05$) than in Malibu. The difference in flow regimes (augmentation in Malibu, none in Topanga) may be a factor in this result.

The soft-bodied algae species composition and abundance was quite different both qualitatively (Table 10-7) and quantitatively (Table 10-8) between Topanga and Malibu. A total of nine non-diatom species including epiphytes, microalgae and macroalgae were found in both creeks. Topanga also had an additional six species compared to 18 additional species found only in Malibu.

Table 10-7 Qualitative Algae comparison Topanga and Malibu sites April 2013.

Phylum	Class	Species	TC3200	TC4500	R3	R4
Chlorophyta	Ulvophyceae	*Cladophora fractus*			P	
		Cladophora glomerata	P	P	P	P
		Rhizoclonium cf crassipellitum				P
		Rhizoclonium heirogliphicum			P	
		Ulva			P	P
Cyanobacteria	Cyanophyceae	*Oscillatoria sp 1*	P			
Streptophyta	Zygnematophyceae	*Mougeotia sp 1*	P			
		Spirogyra sp 1	P			

(P = present)

Table 10-8 Comparison of Dominant Algal Species (um^3/cm^2) Topanga and Malibu 2013.

Species	**TC4500m**	**TC3200m**	**Malibu R3**	**Malibu R4**
BOTH CREEKS				
Cladophora glomerata (macroalgae)	7,633,247,643	1,628,106,255	129,169,840,060	305,656,565,660
Oedogonium sp 1 (microalgae)	12,189,982		5,253,923	4,591,843
Scenedesmus communis		24,186		46252
Scenedesmus dispar		5,296		3,771
Cladophora glomerata (microalgae)	16,814,197,379		7,147,700,819	
Heteroleibleinia	306,900		1,401,223	
Leptolyngbya sp 1 (microalgae)		4,502,054	6,181	798,553
Phormidium sp 1	3,454,135	2,222,162		54,049
Chantransia sp 1 (microalgae)		2,855,514	3,715,403	799,116
TOPANGA ONLY				
Cyanophyceae 5				
Homoeothrix janthina	11,352	215,030		
Komvophoron				
Oscillatoria limosa	157,910	14,191,066		
Phormidium sp 2		152,622		
Mougeotia sp 1	1,806,947,786			
MALIBU ONLY				
Ulva			1.615E+11	3.434E+09
Chlorophyta 1 (ephiphyte)			19	3
Chlorophyta 1 (microalgae)			5,308,6427	
Chlorphyta 2 (microalgae)				3,376
Chlorophyta 4			1,966,744	
Ankistrodesmus falcatus			11,846	
Pediastrum boryanum				12,861
Chamesiphon incrustans			470,312	35,513
Cyanophyceae 11			14,716	
Xenococcus sp 1			88,220	
Scenedesmus armatus				62,891
Scenedesmus ellipticus				30,352
Scenedesmus obliquus			1,458	
Heteroleibleinia (microalgae)			1,401,223	249,443
Leptolyngbya sp 1 (microalgae)			6,181	
Psuedanabaena sp 1				3,022
Xenococcus sp 1			88,220	
Spirogira sp 1				179,791,886

10.4.4 Index of Biotic Integrity (IBI) Analysis

Table 10-9 summarizes the results of three different possible indices, S2 (soft algae only), D18 (diatoms only) and H20 (hybrid incorporating both diatoms and soft algae). Each index was based upon different metrics, but when combined provide relative comparisons that suggest that results for Topanga and Malibu are consistent between indices.

Fetscher et al. (2104) provided a detailed explanation of how these indices were developed, vetted and scaled. Reference conditions were based on evaluation of sites with minimal anthropogenic influences and then checked against possible landscape level factors such as basin geology, gradient, elevation and land cover. Based on their analysis, the boundary between reference and non-reference sites for the H20 index was 57. The upper reach in Topanga meets the reference criteria in 2014 and is just a bit under in 2013. The lower reach in Topanga and both reaches in Malibu would fall into the stressed and disturbed category.

Table 10-9 Comparison of southern California Periphyton IBI Indices for Topanga and Malibu 2013.

Year	SampleID	S2	D18	H20	totalDiatomCount
2013	TC3200	35	46	45	513
2014	TC3200	NA	46	NA	600
2013	TC4500	42	50	55	506
2014	TC4500	53	58	61	595
2013	Malibu - R3	28	58	51	556
2013	Malibu- R4	22	46	42	556

10.4.5 Chlorophyll a and Ash Free Dry Mass

Dodds et al. (1998) developed a trophic classification system for stream based on mean chlorophyll values. Oligotrophic systems usually have less than 20 mg m-2, mesotrophic systems range between 20-70 and eutrophic systems are greater than 70.

Using that scale, both Topanga and Malibu Creeks are in the oligotrophic (non-eutrophic) category, although this data represents a snapshot collected during a drought condition and may not be representational of the creek system over time. Levels of chlorophyll a in excess of >0.66 mg m-2 can be found in either nutrient poor waters with higher than normal temperatures, or in cold water where they can be indicative of excessive nutrient inputs (CWAM 2013). As shown in Table 10-10, the Topanga samples showed mixed results, but the Malibu samples, although higher than the CWAM threshold, were still within the limits of the reference site range (Fetscher et al. 2013)

Recent South Coast ecoregional analysis of 331 sites in 2007-2009 evaluated both methods and found that Ash Free Dry mass (AFDM) results may be more representative of algal biomass and that chlorophyll a has more potential for rapid degeneration and laboratory error, which can cause lots of variation (Fetscher, et al 2013).

Table 10-10 Chlorophyll a and Ash Free Dry Mass Results, Topanga Creek (2013, 2014) collected by RCDSMM and Malibu Creek (2013) collected by Aquatic Bioassay Consulting Laboratories, Inc.

Metric	TC4500-4650m 2014	TC4500-4650m 2013	TC3200-3350m 2014	TC3200-3350m 2013	Malibu R-4 2013	Malibu R-3 2013	**Reference Site Range**
Ash Free Dry Mass SM 2540 (mg/cm^2)	2.76	7.81	6.11	10.85	11	12	**8-27 mg m^{-2}**
Chlorophyll a SM 10200 H (mg m^{-2})	0.476	0.863	0.339	1.326	8	15	**6-27 mg m^{-2}**

10.4.6 Water Quality and Physical Habitat Conditions

Comparison of the physical habitat characteristics of both sampling sites in Topanga and Malibu Creeks suggests that Topanga has more optimal conditions overall, but Malibu has greater average depth at the sampling sites (Table 10-11and 12). The percent canopy is also much higher in Malibu than Topanga. The percent cover of macroalgae (filamentous algal mats) was significantly higher in Malibu compared to the higher level of macrophytes (vascular herbaceous plants in the wetted channel) observed in Topanga. This relates to the very low flow condition resulting in shallow depths in Topanga Creek, which has fostered extensive growth of watercress, various mint and Cyperus species in the channel. The concern with high levels of either macroalgae or macrophytes is that they can limit growth of beneficial microalgae by shading the substrate, reducing the food source (e.g. primary consumers such as diatoms), benthic scraper/grazers and in extreme cases even alter hydrologic patterns (Fetscher et al 2013). Subsequent decomposition of the macroalgae can reduce available dissolved oxygen as well (Quinn and Gilliland 1989).

Table 10-11 Physical Habitat Assessment Comparison between Topanga Creek (2013, 2014) collected by RCDSMM and Malibu Creek (2013) collected by Aquatic Bioassay Consulting Laboratories, Inc.

Habitat Parameter	TC4500-4650m 2014	TC4500-4650m 2013	TC3200-3350m 2014	TC3200-3350m 2013	Malibu R-4 2013	Malibu R-3 2013
Instream Cover	16	17	15	15	11	12
Sediment Deposition	16	17	15	15	8	15
Channel Alteration	20	20	20	20	16	20
REACH TOTAL	52	54	50	50	35	47
Condition Category	Optimal	Optimal	Optimal	Optimal	Suboptimal	Optimal

Table 10-12 Summary of Water Quality and Physical Habitat Conditions in Topanga Creek (2013, 2014) collected by RCDSMM and Malibu Creek (2013) collected by Aquatic Bioassay Consulting Laboratories, Inc.

Location	TC4500-4650m 2014	TC4500-4650m 2013	TC3200-3350m 2014	TC3200-3350m 2013	Malibu R-4 2013	Malibu R-3 2013
Water Quality Measures						
Water Temperature (°C)	14.7	16	14.9	14.7	16.4	13.3
Air Temperature (°C)	14.2	17	18	15.9	NR	NR
Dissolved Oxygen (mg/l)	7.34	7.65	7.65	9.26	4.8	7.1
pH	8.29	6.7	8.27	6.36	7.5	6.6
Specific conductance (µS/cm)	NR	1441	1423	1375	1873	1867
Salinity (ppt)	0.0	1.5	1.0	0.0	0.96	0.95
Alkalinity (mg/l) (Test strip)	NR	300	NR	300	NR	NR
Turbidity (NTU)	4.26	0.4	0.38	NR	NR	NR
Nitrate – N (ppm)	NR	0.0	NR	0.0	NR	NR
Nitrite – N (ppm)	NR	0.01	NR	0.0	NR	NR
Ammonia N (ppm)	NR	0.18	NR	0.0	NR	NR
Orthophosphate (ppm)	NR	0.17	NR	0.16	NR	NR
Time Sampled	0930	0930	0900	0910	0810	1045
Physical Habitat Characteristics						
Reach Length (m)	150	150	150	150	150	150
Average wetted width (m)	4.5	4.4	4.0	4.2	13.5	4.4
Average depth (cm)	10.9	12.6	9.9	12	27.6	10.4
Average velocity (ft/s)	NR	NR	NR	NR	<0.01	0.4
Discharge (m^3/s)	NR	0.004	0.003	0.006	<0.01	0.02
Slope (%)	>3	>3	<3	<3	0.88	2.00
Elevation (m)	400	400	200	200	8	13
Vegetative Canopy Cover (%)	83	65	95	82	21	91
Microalgae Mean Thickness (mm)	0.0	0.0	0.0	0.0	0.02	0.01
*Macroalgae Presence (%)	4	10	5	24	72	76
Macrophyte Presence (%)	18	26	28	18	5	1
Bank Stability (%): Stable	100	91	82	82	0	5
Vulnerable	0	0	18	18	100	95
Eroded	0	0	0	0	0	0
Flow Habitats (%): Cascade/Fall	0	6.5	0	0	0	0
Rapid	0	0	0	0	0	0
Riffle	31.5	19	30	25	5	34
Run	0	4.5	0	75	23	0
Glide	28.5	10	70	0	39	66
Pool	40	60	0	0	33	0
Dry	0	0	0	0	0	0
Average Embeddedness (%)	44	26	49	49	NR	NR
Substrate Size (%): Bedrock	6	6	0	0	0	0
Boulder	33	31	25	23	23	29
Cobble	13	25	7	15	9	20
Gravel	22	12	25	28	13	19
Sand	28	23	44	36	47	22
Fines	0	0	0	0	4	0
Hardpan	0	0	0	0	0	0
Wood	0	0	0	0	0	1
Other	0	0	0	0	4	9

NR= Not recorded/ *=% presence includes unattached and attached macroalgae.

10.5 Discussion

Periphyton are found in all aquatic environments and tolerate a wide range of nutrient levels and overall water quality (Hoffman 1994). Benthic diatoms and soft-bodied algae are important primary producers that rapidly and predictably respond to environmental condition in terms of changes in community composition. Several research efforts in southern California and throughout the United States are examining the potential of utilizing these organisms as water quality indicator species (Porter et al. 2008, Fetscher 2008, Fetscher et al. 2009, CWAM 2013) because of their rapid response to water quality condition changes in nutrient levels (primarily nitrogen and phosphorus), pH and conductivity. For example, diatom saprobity values near sewage outlets showed high correlation to chironimid pollution index, diversity of BMI and diversity of macrophytes (Van Dam et al. 1994). Despite limitations due to increased cost, patchy distribution and sampling errors common to biological assessments, the addition of benthic algae analysis to water quality monitoring provides some important advantages and complements grab water samples and benthic macroinvertebrate data by providing insights into short and long term dynamics of the system. Soft algae are often the dominant biomass in southern California creeks, as in other places, and most likely to exhibit "nuisance blooms", providing greater insight into nutrient loading and uptake patterns (Busse et al. 2003, Luce and Abramson 2005). Benthic algae normally exhibits seasonal patterns related to flow velocity and light availability, but it appears that nutrient loading in the winter months can result in higher benthic algal growth in summer months (Luce and Abramson 2005).

Diatoms in particular have high dispersal rates and short reproduction/growth times that respond quickly to changes in environmental conditions (Lavoie et al. 2008) and the two largest national surface water monitoring programs (Environmental Protection Agency Environmental Monitoring and Assessment Program (EMAP) and the US Geological Survey national Water Quality Assessment Program) both use periphyton indicators due to these characteristics.

Diatoms and soft-body algae can have direct influence on the substrate and flow characteristics, as well as on water quality by increasing nutrient uptake and increasing dissolved oxygen levels (Porter 2008). They are important primary producers and improve habitat for other aquatic species (Porter 2008). They are the foundation of the food web and the basis of the trophic levels found in lower watershed streams. Both diatoms and soft-body algae metrics exhibit rapid responses to levels of stressors and thus examining the changes over time and between locations can help characterize the productivity of the creek (Rimet et al. 2005).

One important caveat to note is that the assignment of a species to a particular metric can vary widely based on geographic range and their consistency as nutrient indicators can vary (Potopova and Charles 2007). This supports the need for development of data specific to southern California in order to properly associate species to water quality tolerances. That being the case, some of the common diatom indicator species with fairly well described Total Nitrogen (TN) preferences, both high and low, were found in both Topanga and Malibu, which provides a somewhat confusing result. This could possibly be a result of inability to differentiate between species in the same genus that appear taxonomically similar, but in fact represent different species with different tolerance preferences. It could also mean that further refinement of the tolerance limits and preferences is needed.

In Topanga Creek, our water quality data indicates that nutrient levels detected in monthly grab samples decreases as water flows downstream from the town, which is the last input of any anthropogenic nutrients. However, the percentage of more tolerant species was higher in the lower reach located approximately 3000 meters downstream of any inputs. A possible cause of this result could be decreasing flows, absorption by macroalgae, or may be associated with the increasing population of invasive red swamp crayfish, which can increase turbidity. These conditions could also possibly explain the increase in Disturbance Taxa observed in 2014 in the lower reach where pools are shallow and runs and riffles are the dominant habitat type.

In addition to responding to nutrient changes and inputs, other factors such as massive growth of *Cladophora sp.* can mask high inputs of nutrients by utilizing and storing nutrients, reducing their detection in the water column. *Cladophora* was the dominant macroalgal species collected in spring 2013 in both survey reaches in Topanga Creek, but it was only observed in the upper reach in 2014. It is also the dominant genus noted with the Rapid Point Count data collected monthly at each water sampling site throughout Topanga Creek and into Topanga Lagoon.

Growth of soft-bodied algae is often controlled by limited available nitrogen or phosphorus. Nuisance blooms are often associated with anthropogenic inputs of these nutrients (Carpenter et al. 1998). Excessive growth of *Cladophora* has been considered to be an indicator or eutrophication (Biggs 1996, Luce and Abramson 2005), although data derived from the NAWQA database (Potapova 2005) found *Cladophora* in a wide range of nutrient concentrations and in moderately alkaline waters having optimum pH of 8.0, and conductivity of 566 µS/cm. It is also more frequently found on rocky rather than softer sediment substrates (Potapova 2005).

Cladophora glomorata is the most common taxa found throughout southern California and appears to be a reliable indicator of high total nitrogen (optimum of 3.14 mg l^{-1}) (Stancheva et al. 2012) and was also the dominant species observed in both Topanga and Malibu. Recent advances in taxonomy suggest that it is possible to distinguish between *C. glomorata* (an indicator of high TN concentrations) and *C. fracta,* which is an indicator of low TN conditions. It is possible that due to the difficulty in making this species level distinction, the lab that analyzed our samples identified everything as *C. glomorata*. Additional investigation of taxonomic effort is needed to explain why such a high TN species is abundant in the low N environment found in Topanga Creek.

Algal abundance can also be limited by hydrological fluctuations when scoured by floods but growing extensively during low flow periods with stable bed sediments typical of southern California summers (Biggs and Close 1989). During the course of this study, there were no flood events. Another potential factor that can affect algal biomass is the abundance of benthic macroinvertebrate grazers and their response to predators (Diehl et al. 2000).

Intensity of grazer foraging can respond to predation threats and result in changes in algal density (Diehl et al 2000). It was beyond the scope of this study to address this directly, but a discussion of possible food web interactions is provided in Chapter 12.

Stancheva et al. (2012) also found that algal species number was significantly correlated with water temperature and increased canopy cover reduced algal biomass. In Topanga, water temperatures ranged between 15-16°C, with canopy cover greater than 65%, which was comparable to the conditions in Malibu site R3, but site R4 had much less canopy cover. The overall IBI scores were not significantly different between the sites. Species in the green algae class Zygnemataceae are considered frequent and abundant in low nutrient streams in southern California and a single species (*Mougeotia sp 1)* was observed in Topanga, as well as *Spirogiyra sp* 1 in Malibu. Given the negligible nutrient levels in Topanga, this is somewhat confusing and contradictory, suggesting that other factors may play a roll in species distribution and/or tolerance ranges.

Some species of cyanobacteria, the next most abundant taxonomic group observed in Topanga Creek, have the ability to fix atmospheric nitrogen and thus are often indicative of streams with low nitrogen levels. These species are usually not found in streams with high nitrogen levels (Porter et al. 2008) and the 11 species found in Malibu Creek were different than the eight species found in Topanga, suggesting a different tolerance to the consistently higher nitrogen levels (>2 mg/l nitrate) found in Malibu Creek (Heal the Bay 2014).

Overall the three different indices of biologic integrity applied showed a consistent picture between sites and creeks for the soft body algae only (S2), diatoms only (D18) and combination of both (H20). These metrics are only recently available and so it is not yet possible to compare the snapshot of conditions in Topanga and Malibu Creeks in 2013 to other sites regionally. Therefore, this information provides a baseline starting point for comparisons over time and in other coastal creek systems.

However, regional and statewide Beneficial Use Risk Classification delineates nutrient unimpaired versus impaired water bodies based on levels of benthic algal biomass measured as chlorophyll a, ash free dry mass, dissolved oxygen levels and pH levels (Fetscher et al. 2013). Disturbance classes were scaled with variables such as land use, road density and number of crossings, presence of dams, pipelines, canals, instream gravel mines and producer mines. Over 500 sites statewide were evaluated, and values from the South Coast ecoregion were consistently higher than for the North Coast or Sierra Nevada ecoregions, which were the lowest. Stressed sites had consistently higher levels of AFDM, chlorophyll a and percent macroalgal cover, but even reference sites in the South Coast ecoregion exhibited consistently high values for these metrics.

Throughout the state, chlorophyll a values ranged from 0.22-1504 mg m^{-2} with a mean of 47 mg m^{-2}, however the south coast median was 25.7 mg m^{-2} (range 8-27 mg m^{-2}). The snapshot data from Topanga and Malibu 2013 were well below that average. The ash free dry mass (AFDM) range throughout the state was 0.07-489 mg $m^{-2}$with a mean of 40 mg m^{-2}, although the south coast median was 17.2 mg m^{-2} (range 6-27 mg m^{-2}). The 2013 data from both Topanga and Malibu creeks were also on the low end of this range (7 -1 2 mg m^{-2}). Scores in southern California are considered to be stressed if they are below 57, which is two standard deviations below the mean for the reference streams (Fetscher et al. 2013). The data from Topanga and Malibu Creeks falls well below the threshold of 30% cover identified by Biggs (2000) and is on the lower end of the reference range (Fetscher et al. 2013), which would suggest that they are stressed, but not yet degraded.

Due to limited data available at this time, it is not possible to develop a consistent hypothesis to explain why there is so little difference between benthic algae communities in Topanga and Malibu Creeks, despite the abiotic differences in stream habitat, flow regimes and nutrient loading patterns. However, this information does provide a snapshot baseline under drought conditions that can be built upon over time.

10.6 Summary

- Examination of diatom and soft-bodied algae communities can provide secondary indicators and multiple lines of evidence to better characterize the responses of southern California creeks to both natural (floods, wildfire) and anthropogenic inputs will allow for better understanding of the dynamics of aquatic systems.
- Diatom and soft-bodied algae data from Topanga 2013-2014 provides a baseline snapshot of low flow conditions.
- A total of 125 diatom species were observed in Topanga Creek in 2013-2014. 46 species, many of them of cosmopolitan distribution, were common to both years, with 40 different species found only in 2013 and 39 species found only in 2014.
- As shown in Table 10-5, the majority of metrics remained similar, with the exception of a decrease in motile taxa present in 2014 at both sites, a decrease in low DO taxa present at both sites in 2014, and a decrease in percent Rhopalodiales in 2014. Percent of sediment tolerant taxa increased slightly in both locations.
- *Cladophora glomorata* is the most common taxa found throughout southern California and appears to be a reliable indicator of high Total Nitrogen (Stancheva et al. 2012) and was also the dominant species observed in both Topanga and Malibu despite their different nutrient levels. This could possibly be a result of inability to differentiate between species in the same genus that appear taxonomically similar, but in fact represent different species with different tolerance preferences. It could also mean that further refinement of the tolerance limits and preferences are needed.
- Using the Southern California Index of Biotic Integrity (Fetscher et al. 2014), application of three different indices of biologic integrity showed a consistent picture between sites and creeks for the soft body algae only (S2), diatoms only (D18) and combination of both (H20). These metrics are only recently available and so it is not yet possible to compare the snapshot of conditions in Topanga and Malibu Creeks in 2013 to other sites regionally.

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11 Conceptual Framework of the Food Web in Topanga Creek

11.1 Introduction

Water quality conditions can in many ways control biological communities, affecting the species diversity, abundance and community structure at a variety of trophic levels. Organisms from diatoms to fish are sensitive to multiple interactions of the physical and chemical conditions within a freshwater system. This study provided a unique opportunity to examine the physical, chemical and biological variables at work in Topanga Creek, which has been colloquially referred to as Topanga "magic". Examination of the fecal indicator bacteria (FIB), in-situ water quality conditions and nutrient levels confirms that although there are numerous anthropogenic inputs into the creek in the upper watershed, these inputs are not responsible for the bacterial exceedances observed at Topanga Beach.

Investigation into FIB, nutrient levels, water quality and benthic macroinvertebrate communities at five creek sites between the town of Topanga (Owl Falls 6500 m) downstream to the upper end of Topanga Lagoon known as the Snake Pit (300 m) was conducted between 2012-2014. Examination of the physical, chemical, and biological variables at each of these sites has begun to illustrate how inputs from the town of Topanga and at other sites further downstream cycle through the system as they move towards the lagoon. While FIB occurrences do occur at creek sites, most prevalently at Owl Falls (immediately downstream of town development) and Topanga Bridge (bridge crossing), they do not translate to beach outlet exceedances. Due to the interrupted subsurface flow that sometimes occurs in summer between 1700 m and 300 m there is no surface connection between the upper lagoon and the creek except during storm events.

Numerous studies have looked at each of these variables independently. Previous studies have also assessed the role that streambed sediments play on fecal indicator bacteria (FIB) survival and decay (Kinnaman et al. 2012, Garzio-Hadzick et al. 2010) as well as the effect of biological influences such as predation and indigenous microbiota on FIB persistence (Korajkic et al 2013). Few studies attempt to examine relationships across trophic levels and between physical and chemical conditions to biological responses in species abundance and diversity, from bacteria to periphyton, benthic macroinvertebrates (BMI) and fish (Feio et al 2007, Griffith et al. 2005).

Although time and resources precluded definitive stable isotope analysis of the food web or development of either a mixing model or structure equation model to more quantitatively characterize the energy flow through the food web, we took this opportunity to qualitatively examine the various trophic levels. The goal was to describe the interactions between FIB, nutrients, sediments (influence on decay rates and nutrient availability), diatom and soft-bodied algae, benthic macroinvertebrates, amphibians, fish and introduced crayfish in Topanga Creek. We incorporated long-term data from annual stream surveys (2001-2014), as well as more detailed data collected as part of the Topanga Source Identification Study in 2012-2014.

One of the more interesting patterns observed in Topanga Creek is that despite inputs of nutrients and FIB in the upper watershed above the town, levels of nutrients and FIB appear to diminish before reaching Topanga Lagoon. First documented in the 1999-2001 water quality study (Dagit 2001), observed again in the 2003-2004 study (Dagit et al. 2004), and continuing to date, this intriguing pattern of sources accumulating in the upper watershed (Owl Falls at 6500 m), a sink in the most natural reach (Scratchy Trail at 4800 m), followed by additional inputs at Topanga Bridge (3600 m), with continued decline downstream when measured at Brookside Drive (1700 m). This strongly suggests that inputs from the upper developed portion of the watershed are not involved with the bacterial exceedances observed at Topanga Beach. It also suggests that nutrient and bacteria levels within the creek are possibly controlled by a complex, synergistic effect of a dynamic carbon, nitrogen and phosphorus energy cycle and a potentially lengthy food web incorporating numerous trophic levels that are able to absorb/utilize nutrient inputs in the more undisturbed reaches of the creek. This discussion therefore focuses on the interactions in Topanga Creek rather than the lagoon and ocean interface.

Increased urbanization resulting in increased percentage of impervious surfaces can affect stream ecology by increasing nutrient concentrations, altering hydrologic patterns, increasing water temperature and light levels (Paul and Meyer 2001). Greater than 10-15% urbanization or conversion to impervious surfaces has been show to negatively affect algae, macroinvertebrates and fish communities (Paul and Meyer 2001). It has been observed that the diversity of aquatic species decreases once the threshold of 8% impervious surface is reached (Riley et al. 2005). The Topanga Creek Watershed has almost 12% impervious surface, yet it retains a diversity of native aquatic species, some of which are sensitive to water quality degradation, such as the endangered southern steelhead trout.

11.2 Elements of the Topanga Creek Food Web

In order to characterize the Topanga Creek food web, it was necessary to summarize the abiotic and biotic elements that contribute to the dynamics of the system. Each of these factors is discussed in detail in other Chapters of this report, as well as in other documents. To facilitate this discussion, the most salient points are summarized below.

11.2.1 Abiotic Factors

Water quantity is quite variable both seasonally and inter-annually. Table 11-1summarizes the wetted width, flow, water temperature and nutrient levels collected in-situ using the California Rapid Bioassessment Protocol (CDFG 1999) during annual stream surveys at two sites in Topanga Creek. The lower reach (3200m) has a lower gradient (<3%) and is located within 100 meters of Topanga Canyon Boulevard. The upper reach (4500m) is isolated from adjacent anthropogenic influences, has a gradient of 3-6% and is more difficult to access. Both of these sites remained fairly stable in wetted width, although flow and depth varied with rainfall. The water temperature was also fairly consistent seasonally, with the highest temperature recorded in 2005 at 3200m when flows persisted for more than 200 days due to the high rainfall and at 4500m during the low flow year 2000. Table 11-1 summarizes the average stream conditions during the 2001-2014 study period.

Table 11-1 Topanga Creek 2000-2014. nd = no data available

Lower Topanga 3200m									
date	**avg flow ft/sec2**	**avg depth cm**	**wetted width m**	**water °C**	**DO mg/l**	**PH**	**conductivity mS**	**Rain to date in.**	**rain total in.**
5/1/01	nd	nd	nd	nd	nd	nd	nd	27.8	27.8
4/23/02	nd	30	5	13	14.86	8	1384	6.88	7.24
5/14/03	0.27	21	5	14.6	9.84	8.9	1632	17.92	17.92
5/3/04	nd	nd	nd	nd	nd	nd	nd	13.16	13.16
5/27/05	0.16	25	5.5	17	6.29	7.5	1130	61.22	61.58
5/8/06	0.22	19.4	5	14.6	9.87	7.8	1520	20.04	21.98
5/1/07	0.05	22	4.5	nd	nd	nd	nd	4.61	4.62
6/30/05	nd	nd	nd	nd	nd	nd	nd	23.08	23.08
4/27/09	0.03	28.6	5.75	13	9.85	7.8	nd	14.97	16.16
4/26/10	0.1	13.2	5	10	nd	nd	nd	24.2	24.4
4/28/11	0.42	30	2.2	15	10.24	nd	1620	30.75	31.44
4/23/12	0.21	17.5	4.7	15.3	14.23	8	951	15.45	16.22
5/2/13	0.03	8.75	2.5	14.7	9.26	6.4	1375	9.44	9.99
5/5/14	0.06	5.5	2.25	14.9	7.6	8.3	1423	6.85	6.85
Upper Topanga 4500m									
date	**avg flow ft/sec2**	**avg depth cm**	**wetted width m**	**water °C**	**DO mg/l**	**pH**	**conductivity mS**	**rain to date in.**	**total rain in.**
2001	nd	nd	nd	nd	nd	nd	nd	27.8	27.8
2002	nd	nd	nd	nd	nd	nd	nd	6.88	7.24
5/14/03	0.43	10	4	14.7	9.18	nd	1694	17.92	17.92
5/4/04	nd	nd	nd	nd	nd	nd	nd	13.16	13.16
5/17/05	0.34	nd	5	15.1	6.99	7.6	1450	61.22	61.58
5/9/06	0.15	28.75	6	15.6	10.24	7.9	1560	20.04	21.98
5/4/07	nd	nd	nd	nd	nd	nd	nd	4.61	4.62
4/29/08	nd	nd	5.1	12.2	11.25	8.3	nd	23.08	23.08
2009	nd	nd	nd	nd	nd	nd	nd	14.97	16.16
4/22/10	1.13	23.6	5.3	10	nd	nd	nd	24.2	24.4
4/29/11	nd	53	7.25	14.8	9.64	nd	1690	30.75	31.44
4/24/12	0.04	18	5.1	14.1	12.56	7.7	1630	15.45	16.22
4/30/13	nd	13.9	5	16	7.65	6.7	1491	9.44	9.99
5/6/14	nd	24.4	5	14.7	7.19	8.3	nd	6.85	6.85

Precipitation

The pattern of precipitation varied dramatically over the years as shown in Figure 11-1. Additionally, the intensity, duration and pulses of storm events also varied, from years with rainfall distributed over several months, to a more recent pattern of isolated storms separated by long dry interludes. It was not possible to correlate these observations with the larger climatic cycles of the El Nino Southern Oscillation or the Pacific Decadal Oscillation, although both could play a role in the rainfall received in the watershed. Complex multi-year cycles of drought, shifting rainfall patterns and intensity of storms characteristic of southern California Mediterranean conditions can play an important role in the variability of streams, which are then linked to changes in the biotic community, and particularly influence the diversity and persistence of BMI (Durance and Ormerod 2007). The County of Los Angeles has been in and out of drought conditions since 2000. However, winter rains were enough to alleviate drought and remove the lowest drought distinction of ‘D0 abnormally dry’ at least temporarily. The winter of 2012/13 was the first winter in a decade that this alleviation did not occur, and the county dove into a more intense drought ‘D3 extreme drought’ (US Drought Monitor 2014).

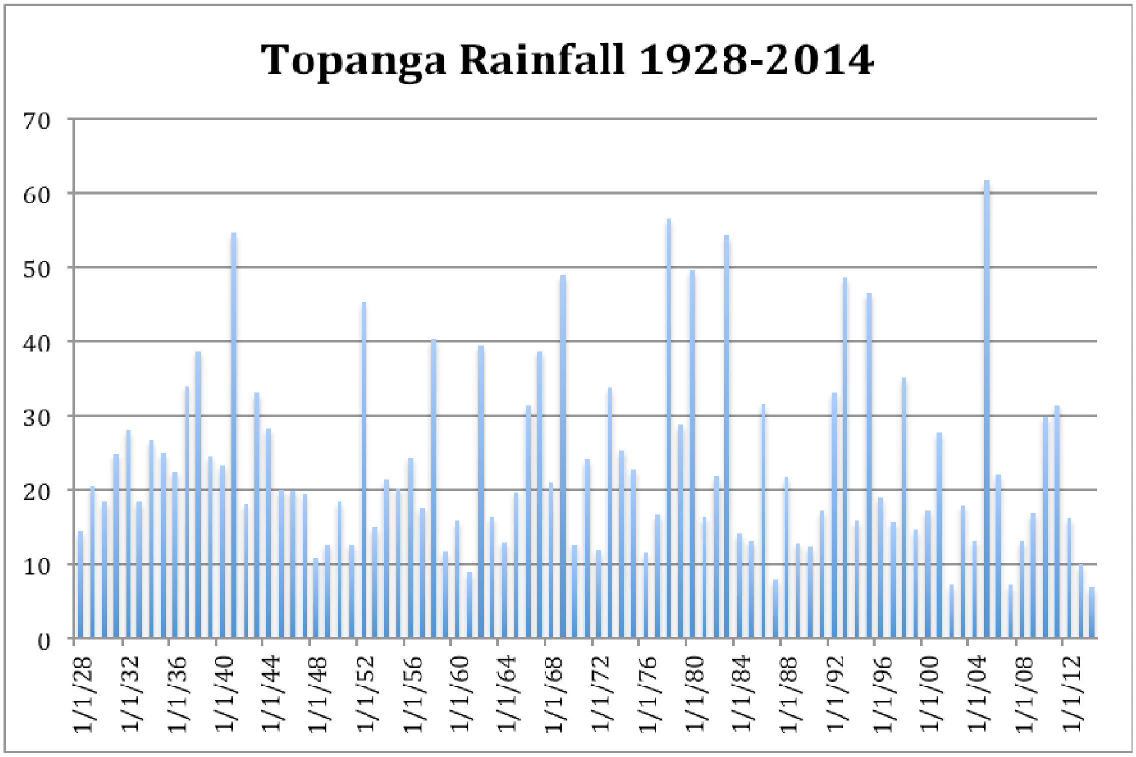

Figure 11-1 Summary of Precipitation in Topanga Creek (based on Los Angeles County Rain gage #318).

Groundwater Influences

The locations of seeps and springs contributing groundwater year round to the main stem of Topanga Creek were mapped in 2005 (GeoPentech 2006). These groundwater inputs are not directly related to the distribution of steelhead trout, although the main refugia pools consistently used by trout receive inputs from groundwater, which may help moderate summer/fall water temperatures (Tobias 2006). Input from these sources can augment flows adjacent and downstream of the sources.

Flow Habitats

The variety and complexity of flow habitats (riffles, runs, pools, etc.) contribute to the diversity of niches available for aquatic species. Underlying geomorphology, especially gradient, determine the distribution and abundance of each habitat type. Topanga Creek contains a wide range of habitat types, but is primarily pool and riffle dominant (Table 7-1). Analysis of the relationship between habitat types and steelhead trout (*Oncorhynchus mykiss*) distribution showed that adults tend to be associated with pools of greater depth and higher gradient (upstream reach), whereas juveniles are found more often in lower gradient (lower reach) and shallow habitats (Krug et al. 2014). Distribution and abundance of this top-level predator can influence the dynamics of the prey community.

Water Quality

Water quality sample sites for this study (Figure 2-1) were selected to reflect the variety of conditions found as Topanga Creek flows downstream from the town through the more isolated canyon, and then adjacent to the highway before reaching the creek mouth at Topanga Lagoon. Sites are as follows: Owl Falls (6500 m), Scratchy Trail (4800 m), Topanga Bridge (3600 m), Brookside (1700 m), and Snake Pit (300 m).

Levels of nutrients measured including nitrate-N, nitrite-N, ammonia-N and orthophosphate were consistently low with isolated spikes, however even the highest levels documented in Topanga Creek were significantly lower than those observed in other regional creeks such as Malibu (Table 6-22). Levels of nitrogen, phosphorus or light can limit stream algal growth, and increases in any of these resources can result in algal blooms (Borchardt 1996). Figure 11-2 summarizes the FIB, nutrient and turbidity levels observed between 2012-2014. The highest values occurred during first flush rain events, which is consistent with observations in most river systems (Surbeck et al. 2006). Phosphates were often in exceedance at Owl Falls, and to lesser degrees at Scratchy Trail and Topanga Bridge downstream. Correlations between high phosphate levels and ENT at Owl Falls suggest there may be a septage or graywater input somewhere in town, but that its effects are diluted to a point where they are undetectable at Scratchy Trail (low ENT).

The role turbidity is playing in the overall dynamics of the food web is not clear. Bioturbation may be having an influence on the BMI community either directly or indirectly, perhaps related to the effects of crayfish (Yamamoto 2010). The effects of turbidity on BMI need further study in Topanga Creek.

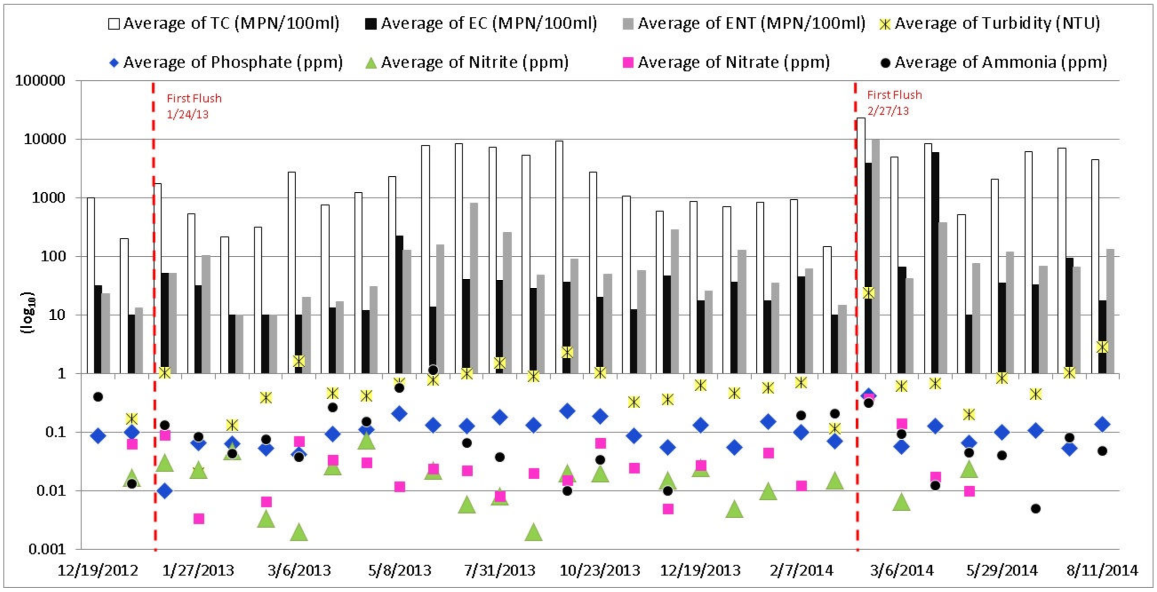

Figure 11-2 Summary of Average FIB and Nutrient Levels in Topanga Creek 2012-2014.

It has been shown that algal communities have a complicated relationship with nitrogen and phosphorus levels in the water column due to storage, uptake patterns that fluctuate depending on seasonal loads, substrate availability and flows which can result in delayed growth responses (Busse et al. 2006, Luce and Abramson 2005). With the low nutrient levels observed in Topanga Creek it is hard to determine if either nitrogen or phosphorus are limiting factors in algal growth or if algal growth is more synergistic with other factors such as flow and light. Biggs (2000) suggests that nutrients influence algal biomass concentration more during periods of low flow. Observations in Topanga Creek suggest that during the low flow period between 2012-2014, overall algal growth was not as high as had been observed during previous low flow periods (Krug et al 2014), potentially suggesting that nutrients were limiting during this time.

The relationship between dissolved oxygen (DO) levels and water temperatures are well documented and levels of DO below 5 mg/l are considered stressful for steelhead trout. These low levels were observed in five out of 21 sample events at Owl Falls (6500 m) and 17 out of 21 sample events at Snake Pit (300 m) during the low flow dry conditions when the pool was isolated and stagnant. Steelhead have not been able to reach 6500 m upstream due to natural stream barriers and only pass through Snake Pit when rains reconnect surface flow sufficiently to permit fish passage. Lower DO levels were significantly correlated to a higher percentage of non-insect taxa and higher DO levels were correlated to lower percentage of non-insect taxa.

Substrate and Embeddedness

Habitat mapping done for the watershed characterization as part of the steelhead trout monitoring program found that the composition of substrate remained fairly consistent over time (Dagit et al. 2007). Pulses of sediment were observed to move through the system driven by storm events, but despite a shift in pool depth at specific sites, overall amount of stream suitable to support steelhead remained fairly constant. The percent embeddedness ranged from 20 to 50% (Stillwater et al 2010). In 2013, the 3200m site was considerably more embedded (49%) than the upper 4500m site (26%), but while the lower site remained the same in 2014, the upper site increased to 44% (Table 7-1). This could reflect either the loss of wetted width as the flows diminished, increased sedimentation, or both. Trout prefer loosely embedded gravels for preparing their redds, and increased embeddedness reduces interstitial niches for many other aquatic organisms. High levels of embeddedness are also associated with reduced biodiversity and abundance of BMI (McGinley et al. 2013).

Bank Stability

Bank instability and erosion can negatively affect aquatic communities by altering substrate composition (increasing fines) and changing habitat types from pools to riffles, or other variations depending on the intensity of the failure. The impacts of bank instability were observed in Topanga Creek in 2008, when Caltrans blew up a boulder that blocked Topanga Canyon Boulevard, resulting in the collapse of a rip rap bank into the creek channel, which changed a consistent refugia pool habitat into a riffle habitat (RCDSMM *unpublished data*).

Due to the geology of the steep canyon walls that define much of the main stem of Topanga Creek, overall bank stability is quite high (Table 7-1) and erosion from upstream sources is episodic.

Instream Habitat Complexity

Instream habitat complexity includes abundance levels of filamentous algae, aquatic macrophytes, boulders, woody debris, undercut banks, overhanging vegetation, living tree roots and artificial structures. These provide a variety of niches for aquatic species from bacteria to fish. In 2013 and 2014, pools, riffles, glides and runs were the dominant habitat available. As flows decreased during 2014, the proportion of runs decreased in the lower reach (3200m) and the percentage of glides and pools decreased in the upper reach (4500m) (Table 7-1).

Canopy Cover and Riparian Vegetation

Canopy cover is fairly high (>80%) throughout Topanga Creek and appears to be increasing with the low flow condition and lack of storm events to clear the channels of macrophytes. The riparian vegetation of Topanga Creek is dominated by trees and saplings (>5 m) in the lower reach, but is dominated by herbs and grasses in the upper reach, which is more defined by steep rock walls (Table 7-1). Invasive plants are found throughout the watershed, including large stands of *Arundo donax*, and increasing spread of cape ivy.

11.2.2 Biotic Factors

Microbial Communities

Although it was not possible to characterize the non-fecal microbial community in Topanga Creek, it is important to recognize that the growth and decay of both fecal and non-fecal microbes is a critical underlying factor in the function and response of Topanga Creek to natural and anthropogenic inputs. The role of indigenous microbiota on the persistence and rate of decline of FIB is still not clearly identified but predation and competition impacts, as well as limits to FIB reproduction are important considerations when examining the dynamics of the creek. Using laboratory microcosms to examine samples from Topanga Creek, the growth and decay of bacteria in sediment identified that decay rates were faster in the more natural undisturbed reach samples at Scratchy Trail when compared to the upstream site at Owl Falls, which is closest to urban inputs (Zimmer-Faust *unpublished data*). This is consistent with observations that Scratchy Trail represents a reach where natural cycling of nutrients is most functional. However, the sediment microcosm results from Brookside Dr. (1700 m) suggest that nutrient cycling may be less downstream of Scratchy Trail. More information on these interactions was beyond the scope of this study but presents an interesting question for subsequent work.

Benthic Algae

The abundance of benthic algae can be influenced by abiotic factors such as flows and flood scouring, stability of the sediments, by inputs of nutrients or limitations of nitrogen and phosphorus in low nutrient systems, and finally by the effects of grazing by aquatic organisms. There were no flood events during the course of this study (2012-2014) that were sufficient to mobilize the substrate or scour benthic algae, macroalgae or macrophytes, although such flows were observed in 2005, 2008, 2010 and 2011. Topanga Creek has relatively low levels of nutrients, making it is possible that nitrogen (N) and phosphorus (P) are limiting factors for growth. The Mediterranean climate is characterized by long undisturbed growing season for algae, which suggests that available N and P may ultimately not be the only limiting factor, but rather that available light, stream substrate composition and wetted channel may also be important factors (Busse et al. 2006).

Although a dense benthic diatom algal biomass was not observed during this study, our data were unable to distinguish between possible nutrient uptake/availability limitations versus effects of grazers. Once established, filamentous algae are inedible for many aquatic insects (Cummins 1973) but foraging by grazers can both stimulate (under less intense conditions) and reduce (under more intense foraging pressure) density and cover of benthic algae (Diehl et al. 2000). For example, mayflies (*Baetis sp*) are important benthic algal grazers and their population fluctuates with availability of algae, especially that on epibenthic substrates. Additionally, their use of these food resources is dependent on the type of predators they are avoiding. When present, trout can alter the behavior pattern of *Baetis* foraging by making it more risky to forage during the day, or in particular areas, thus potentially increasing the algal density in more exposed areas, and decreasing the density in more protected areas (Diehl et al. 2000).

The species composition of benthic diatoms and soft-bodied algae observed in Topanga is based on such limited samples that it would be premature to make much of the snapshot baseline available at this time.

Benthic Macroinvertebrates

As primary consumers of allochthonous (terrestrial leaf litter derived) and autochthonous (aquatic plants derived) detritus, benthic macroinvertebrates are the most basic link between both aquatic and riparian vegetation and the rest of the river community. Filling distinct feeding niches, some species shred whole leaves and stalks, others scrape up the film left behind, ultimately releasing a large pool of nutrients that can be absorbed by higher trophic levels. Analysis of functional feeding group (FFG) diversity can shed light on how nutrients begin to flow at these primary trophic levels. In addition to FFG designations, many families, genera, or species have assigned tolerance values 0-10 (CAMLnet. 2003) that designate the organism's ability to live in polluted waters.

Another key feature of benthic macroinvertebrates is their tendency to reveal current and past ecological disturbance. Some taxa, such as mosquitoes, may appear and disappear within a week, while others, like some common dragonflies, develop under water over the course of a year or more (Voshell 2002). Therefore, shifts in species composition may be the result of a current disturbance event or one that occurred within the year. Habitat preferences, limitations, and additional life-history traits have been described for many macroinvertebrate species (Vieira et al. 2006). Indexes of Biotic Integrity (IBI) have been developed using this information to evaluate BMI community composition and distribution and to assign numeric and descriptive scores of ecological health.

A total of 17 BMI samples were collected at each sampling location from upstream to downstream as part of this study. This augmented information compiled by analyzing the annual stream survey BMI collections between 2003-2014. A summary of the SCC-IBI for Topanga Creek is found in Table 8-3 and 8-4. Examination of the samples from upstream to downstream confirm our hypothesis that BMI communities improved the further they were from human influences.

The number of BMI individuals collected from the annual springtime stream surveys from Upper and Lower Topanga Creek ranged from 104 to 3516, representing six phyla, 21 orders, and a total of 76 taxa. The majority of individuals fell within the phylum Arthropoda and class Insecta, followed by the subphylum crustacean including class Ostracoda and order Amphipoda. To date, the invasive New Zealand mud snails (*Potamopyrgus antipodarum*) have not yet been observed in Topanga Creek.

From 2003-2012, *Baetis sp. (blue-winged olives),* a prolific genera of small minnow mayfly was the first or second most abundant taxon every year in both Upper and Lower reaches (Figure 8-5). *Baetis sp.* made up between 33-79% relative abundance (RA) in Upper Topanga, and 13-67% in Lower. The family Baetidae are characterized as strong swimmers, most prevalent in flowing, shallow waters with ample cobbles and/or pebbles (Voshell 2002). *Baetis sp.* are collector-gatherers and have a tolerance value of 6. In 2013 and 2014, *Baetis sp.* were no longer dominant and in fact comprised less than 10% RA of all four samples. Chironomidae, or non –biting midges, which had previously made up between 5-36% shifted to occupy 63-72% of all samples 2013-2014. Chironomids are also primarily collector-gatherers, and are ascribed a family-wide tolerance value of 6. However, the Chironomidae family is extremely diverse, including over 1,000 species, and thrive in equally diverse habitats. Chironomids were identified to sub-family or tribe for a few select samples, and similar taxa were found before and after 2013.

Overall SCC-IBI scores for Topanga Creek were Fair to Very Poor between 2003-2014. Many of the samples had too few individuals collected to be analyzed by the SCC-IBI, which means that they were extremely poor. It is not clear if this might be due to heavy predation by amphibians, crayfish and steelhead or if it is an accurate reflection of the BMI community response to environmental conditions (low flow, low dissolved oxygen). In any case, it is a cause for concern.

Invertebrates – Crayfish

Low flow, shallow conditions such as have been present since 2011 provide preferred habitat for red swamp crayfish (*Procambarus clarkii*) (Voshell 2002), and the lack of flushing storm pulses that have been shown to reduce their numbers has resulted in the population explosion of this species in Topanga Creek.

P. clarkii grow rapidly, maturing within three months after hatching and can reproduce twice a year in warm conditions (Barnes 1974, Vodopich and Moore 1999, Safra et al. 1999). Furthermore, large healthy females typically produce 600 viable young (Barnes 1974, Vodopich and Moore 1999, Safra et al. 1999). The generalist and predatory feeding habits of this Gulf Coast native have been linked to observed declines in macrophyte abundance (Feminella et al. 2006, Rodriguez et al. 2005), macroinvertebrate diversity (Correia et al. 2008), increased bioturbation (Mueller 2007, Yamamoto 2010), and amphibian species richness and recruitment (Gamradt and Kats 2002, Cruz et al. 2006, Ficetola et al. 2011). *P. clarkii* consume an array of plant and animal matter, aquatic vertebrate eggs and larvae, aquatic invertebrates, and can affect food webs on a polytrophic scale.

Pease and Wayne (2013) also observed that Pacific tree frog tadpoles (*Pseudarcris regilla*) responded to predation by crayfish both behaviorally and morphologically by selecting for deeper tail muscles. Gamradt and Kats (2002) conducted amphibian surveys from 1981-1986, and identified ten Santa Monica Mountain streams supporting populations of California newts. When the surveys were repeated in 1994, newts were missing from three of those 10 streams. Further study documented that *P. clarkii* consumed newt egg masses, as well as attacked adults (RCDSMM *unpublished data*).

A short term removal effort conducted by the Watershed Steward Members and RCDSMM Stream Team volunteers between Fall 2013 and spring 2014 suggests that these indiscriminant predators are directly affecting the BMI community and potentially competing for scarce food resources with native amphibians and fish. Additionally, they have been observed to directly attack CA Newts and the numbers of young of the year trout was reduced as the population of crayfish increased (Figure 11-3). While there are numerous other factors that could play a role in that observation (reduced numbers of redds, increased young of the year mortality from drought or predation), it is difficult to ignore the potential for crayfish to be impacting recruitment of steelhead.

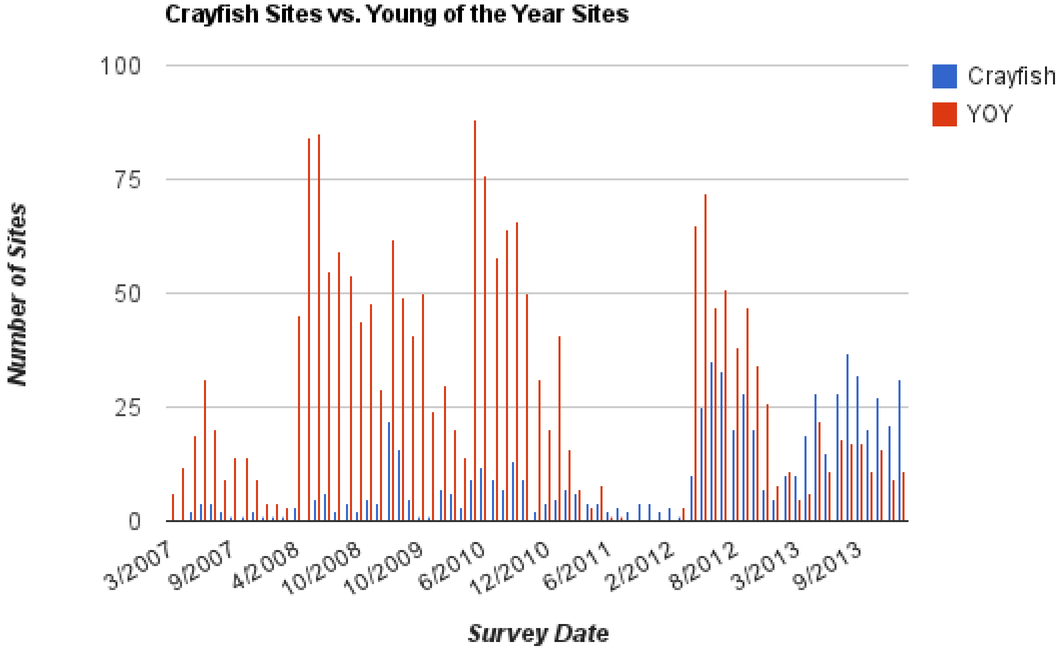

Figure 11-3 Comparison of Young of the Year Trout and Crayfish populations based on snorkel surveys in Topanga Creek 2007-2014.

Herpetofauna

Topanga Creek is home to 23 of a possible 33 species of amphibians and reptiles known from the Santa Monica Mountains (De Lisle 1986, Dagit and Webb 2002). A number of these species are commonly or sporadically observed inhabiting the main stem of Topanga Creek below town. The most commonly observed species are the Pacific tree frog (*Pseudarcris regilla*) and the California tree frog (*Pseudarcris cadaverina*) both of which feed on a variety of invertebrates. Preliminary results of data collected during the annual stream surveys suggests that their numbers are declining as the number of crayfish increase, although this could be related to the rainfall patterns as well. Additional analysis of data is needed to confirm this observation (RCDSMM *unpublished data*).

Prior to the increased abundance of crayfish, California newts (*Taricha torosa*) were regularly observed. They too rely upon a variety of small invertebrates as their food source as adults, and may consume decaying organic matter during their larval stage. The number of CA newt egg masses and adults observed within the study reaches have dropped as the number of crayfish has increased (Figure 11-4). Gamardt and Kats (2002) have documented that newts avoid streams with crayfish but return to them following crayfish removal by flood events.

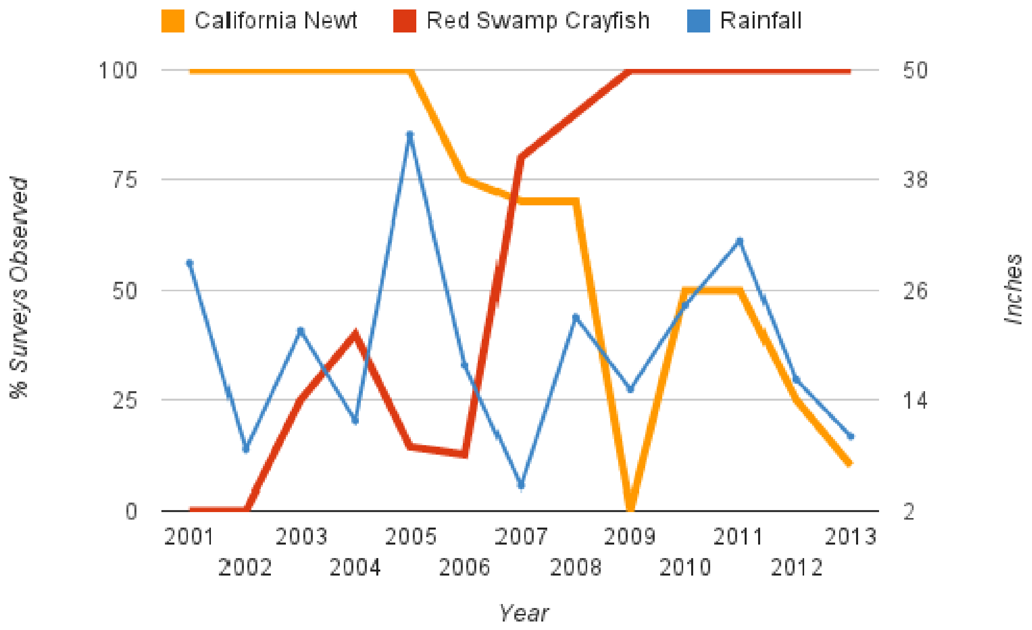

Figure 11-4 Comparison of CA newt and Crayfish observations during annual stream surveys in Topanga Creek. (Note: data is not continuous, but lines were used to highlight the changes observed).

Another aquatic species frequently observed in the study reach is the two-striped garter snake (*Thamnophis hammondi*). The preferred diet of these snakes include tadpoles, newt larvae, small frogs and fish and occasionally fish eggs.

Potentially present and contributing to the diversity of the aquatic food web but rarely observed in the study reach are western toads (*Anaxyrus boreas*) who consume invertebrates as adults and algae and detritus as tadpoles; western garter snakes (*Thamnophis elegans*) which will eat whatever they can find, and occasionally a southwestern pond turtle (*Actinemys marmorata*) straying from the upper watershed (DeLisle 1986). These omnivores will eat algae, some macrophytes, invertebrates, tadpoles, crayfish, and small fish or frogs that are captured and consumed in the water.

Fish

Three native fish species are found in lower Topanga Creek, but the tidewater goby (*Eucyclogobius newberryi*) is confined to the lower and upper portion of the lagoon and rarely observed further upstream. Both southern steelhead trout (*Oncorhynchus mykiss*) and arroyo chub (*Gila orcutti*) are distributed throughout the study reach (Krug et al. 2014). In spring 2014, fathead minnows (*Pimephales promelas*), an invasive exotic fish most often used for bait were detected throughout the study reach of Topanga Creek. All of these species are known to consume a wide variety of aquatic invertebrates and even some algae, but only steelhead trout have been documented eating other fish and crayfish (Krug et al. 2012). The abundance of arroyo chub varies seasonally with increased numbers in summer and fall

(RCDSMM *unpublished data*). This corresponds with the increased numbers of amphibian tadpoles, larval newts and juvenile steelhead trout observed during the same time frame. It is possible that the increased competition for BMI resources at the time of the annual spring stream surveys plays a role in the low numbers of individuals collected.

Steelhead trout were extirpated from Topanga Creek during the 1970-80's but recolonized in the 1990's (Bell et al. 2011). Since that time, the population has increased both in abundance and distribution throughout the creek. Prior to the high flows in 2005, trout were restricted to the reaches below 4400m, but have expanded upstream to the natural limit of anadromy since (Krug et al. 2014). The variability of the population reflects both seasonal trends (increases with young of the year in spring) and response to rainfall (Table 11-2). During low rain years, habitat limitations due to low flow conditions restrict movement through the creek, often isolating individual fish in specific reaches for extended periods of time. Adults are most often found in refugia pools, and juvenile fish are found more often in shallow habitat types, including riffles, runs and glides. A large decline in the number of fish observed occurred following a major storm event in March 2011, when the creek was connected to the ocean for several days, allowing juvenile smolts to out-migrate (Krug et al. 2014). Predation by trout in specific pools and short reaches of the creek can be intense and consistent over time (RCDSMM *unpublished data*).

Table 11-2 Average number of each size class based on Topanga Creek snorkel survey observations 2001–2013. (Krug et al. 2014)

Year of observation	Juvenile (<100 mm)	Intermediate (100–250 mm)	Adult (>250 mm)	Total
2001	25	25	3	53
2002	34	56	6	95
2003	6	34	19	59
2004	46	50	12	103
2005	6	46	20	71
2006	62	68	40	170
2007	35	36	16	86
2008	250	47	18	316
2009	112	81	14	209
2010	115	125	13	253
2011	9	85	20	114
2012	68	21	7	95
2013	28	26	2	56

Stomach contents taken from trout during mark recapture events in November and March of 2010-2013 using gastric lavage, showed that trout in Topanga Creek, similar to elsewhere, are opportunistic feeders (Figure 11-5). Aquatic insects are the preferred prey of trout as they are generally higher in caloric values compared to other potential prey items. When aquatic insects were readily available, trout in Topanga Creek consumed mainly aquatic insects, however, during summer months when aquatic insects were less available, they supplemented with terrestrial insects. Arroyo chub, crayfish and snails were also eaten occasionally. After 2012, as low flows persisted due to lack of rainfall, crayfish increased in abundance throughout the creek, and prey found in trout stomachs consisted more of crayfish and less of aquatic macroinvertebrates (Krug et al. 2012). This could have been due to a number of factors, including lower aquatic insect abundance and biomass, increased biomass of crayfish and increased ease of catching crayfish. A switch in prey consumption by a top-level predator can affect prey population dynamics. Here, it seemed like the lack of rainfall and low flow conditions were a major factor contributing to the increase in crayfish and decrease in benthic macroinvertebrates, suggesting that abiotic factors are an important driving force behind food web dynamics in Topanga Creek.

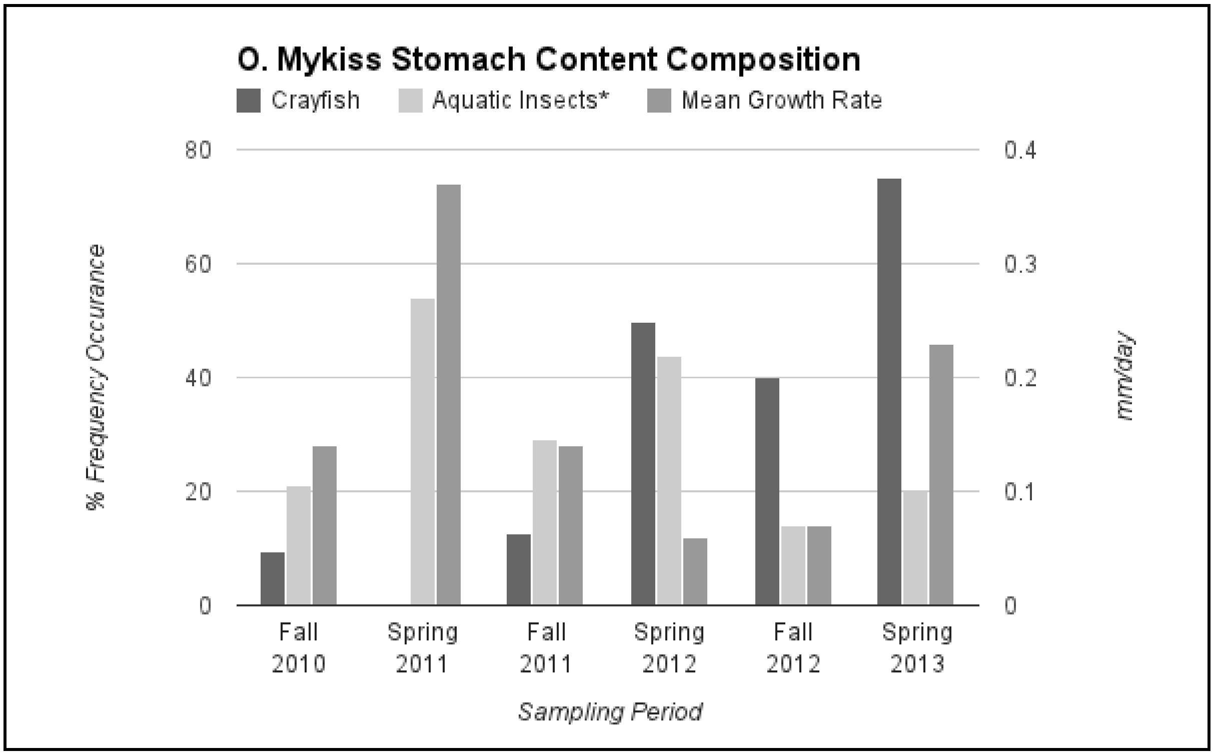

Figure 11-5 *O. mykiss* stomach content composition (Krug et al. 2014)

11.3 PRELIMINARY Conceptual Model of the Topanga Creek Food Web

One of the principle questions in ecology is how a variety of abiotic and biotic factors limit or regulate resources throughout a system. Are predators controlling the abundance of primary producers, which is known as top-down theory, or is the availability of resources (i.e. carbon, nitrogen, phosphorous, organic matter) needed to support primary producers limiting their abundance (bottom-up theory)? How do biological communities respond to changes in flow or other disturbances? The debate continues concerning the relative importance of each of these forces, as well as the recognition that most biological systems are extremely complex and that both forces are important and dynamic (Porter 1992).

The model of algal growth and biomass controlled by resource supply (bottom-up), disturbance, and grazing may not fit Mediterranean stream conditions because of the extended low flow summer periods and the effects of abiotic factors on algae productivity patterns (Busse et al. 2006). Flow patterns can also cause seasonal changes in BMI (Hurtubia 1973) resulting in fluctuating abundance and functional feeding group composition, that in turn impacts the density and abundance of benthic algae. One of the limitations of the top-down model is that it is often difficult to accurately identify the diversity of prey species taken by each predator species, the breadth of food niches, and the competitive impacts of multiple predators in a limited system (Hurtubia 1973, Diehl et al. 2000, Power 1992).

Finally, it is important to examine these relationships within the context of watershed landscape conditions, especially the potential implications of both direct and indirect influences of urbanization, such as the percent of impervious surface (Riley et al. 2004).

Below we attempt to examine the possible constructs of top-down forces, bottom-up forces and a more complex interaction using abiotic and biotic observations from Topanga Creek.

Top-Down Scenario:

In this scenario, the key driver of the Topanga Creek food web would be steelhead trout as the top predator, consuming crayfish, other fish, tadpoles and both terrestrial and aquatic insects. Crayfish, arroyo chub, tree frogs and newts make up the intermediate trophic levels, as they are both prey of steelhead and predators on BMI. The composition of the BMI community changed in 2013, shifting away from dominance by Baetidae, and becoming more dominated by chironimids, amphipods and snails. Since 2001, the numbers of both trout and crayfish have increased, suggesting that food was sufficiently available to support growth and reproduction. The different styles of predation (trout are visual predators more active during the day as compared to crayfish who are more nocturnal feeders) could mean that these predators are able to co-exist by creating predation pressure 24 hours a day. This continued predation pressure, combined with the low flow conditions of the past two years could be a factor associated with the observed decline in Southern California Coastal Index of Biotic Integrity (SCC-IBI) BMI scores.

Bottom-Up Scenario:

Availability of resources (carbon, nitrogen, phosphorous, organic matter) are potential factors that can limit growth of microbes and algae, as well as BMI. BMI are key to the recycling of detritus, resulting in conversion of leaf litter into dissolved nutrients that can be easily accessed by bacteria, algae and other microbes, accelerating and supporting their growth. Low levels of both course and fine organic matter, combined with a limited number of representatives of various functional feeding groups were observed. The overall low levels of nitrates, nitrites, ammonia and phosphorous observed throughout Topanga Creek could be due either to efficient uptake and absorption of these resources by the biological community, or simply that Topanga Creek is limited by low input levels of these resources. This condition can shift in response to nutrient loading such as occurs during storm events. The pattern of low nutrient levels in the water samples, low density of algae, as well as the low

SCC-IBI scores for BMI, suggests that the creek could either be resource limited, or that the low levels of primary producers are strongly influenced by heavy predation by amphibians, crayfish and fish.

Integrated Food Web Scenario:

Figure 11-6 illustrates the integration of both the top-down and bottom-up processes that may be occurring in Topanga Creek. In the integrated scenario, top-down and bottom-up forces are in a continuous feedback loop, with each trophic level responding to on-going changes throughout the system. The pattern of water column nutrient reduction observed between the inputs at Owl Falls (6500 m) and the levels observed at Scratchy Trail (4800 m) suggests that these inputs support increased productivity at Scratchy Trail, which is reflected in a more abundant benthic algae and BMI community, which in turn supports a higher density of predators (amphibians, crayfish and fish). Snorkel survey data shows increasing numbers of crayfish, chub and larger trout individuals also observed in that reach (RCDSMM *unpublished data*).

However, nutrient levels downstream of Scratchy Trail are relatively consistent, and both the benthic algae and the BMI community metric scores decline from Topanga Bridge (3600 m) downstream to the lagoon. This suggests that resource limitations, combined with the presence of predators could be controlling the community structure in these lower reaches of the creek. These observations occurred within the context of variable, but predominately low flow conditions experienced since 2002, especially downstream of Topanga Bridge. A shift in the dominant BMI taxa from Baetid/Simulidae to Chironomid/Amphipod suggests that the combination of flood events, as well as extended low flow periods has restructured the BMI community. Combined with the increasing numbers of steelhead trout and crayfish since 2001, it appears that the overall condition of Topanga Creek has changed.

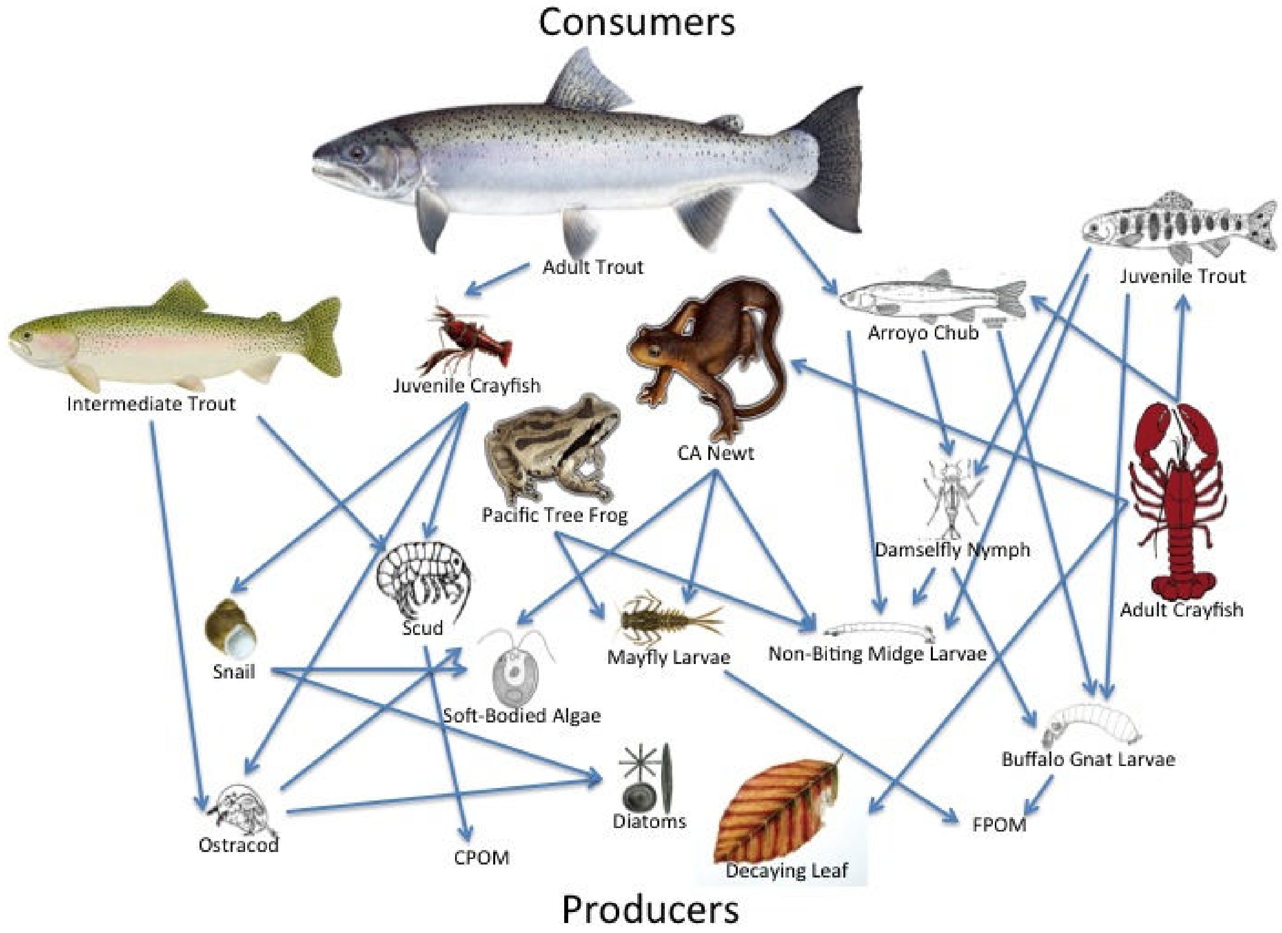

Figure 11-6 Conceptual model of the Topanga Creek Food Web.

11.4 Discussion

Food web interactions in aquatic systems can strongly influence biogeochemical cycling, fisheries production, and responses to anthropogenic influences (Brett and Goldman 1997). Due to the complexity of both abiotic (fires, floods, drought, climate change and anthropogentic inputs) and biotic (introduced invasive species) stresses over time it is important to have long-term perspectives on trophic level and food web dynamics, especially in Mediterranean ecosystems, where both seasonal and annual changes, especially drought, can shift community structure on many levels (Resh et al. 1988, Resh et al. 2013). In Topanga Creek, we are interested in determining how these processes are involved in uptake of nutrients and how they accomplish the absorption of anthropogenic inputs from the upper watershed. We are also concerned about the possibility that excessive loading could unhinge these processes and the consequences to aquatic diversity that might result from that failure. Abiotic changes can confound our ability to distinguish changes caused by natural variability from changes caused by anthropogenic stressors (Morais et al. 2004). Biotic pressures like predation and intensify as space and resources become limited as water levels drop (Robson et al 2011). These synergistic and dynamic factors make it extremely difficult to identify tolerance thresholds for anthropogenic inputs over which the creek will no longer be resilient.

Collected information on BMI, crayfish and trout abundance provide the most information on food web interactions at this time. Since 2001, the populations of both crayfish and trout have continued to increase, while the BMI community biotic integrity appears to have declined. There are several ways to interpret this information. The redundancy hypothesis posits that as long as the functional feeding group is represented, and that as long as trophic levels remain uniform (even with different species present at each level) both energy flow and ecosystem processes will continue to work in the same way (Power 1992). By contrast, the keystone species hypothesis suggests that certain species are critical to the function of the food web and cannot be replaced by others with similar, but not exactly the same role (Power 1992, Morais et al. 2004). This is of concern in Topanga, where management is focused on supporting the continued survival of steelhead trout, which are considered to be an umbrella species. The theory has been that if the creek is able to support a reproducing population of steelhead, then other aquatic species will benefit as well.

Other studies have found that the food web interactions of BMI are often species specific, and influence nutrient cycling and energy flow throughout the food web (Covich et al. 1999), thus even slight shifts from baetids to chironomids, could potentially have ripple effects on the dynamics of a system. Forrester et al. (1999) examined the relationship between fish biomass, baetid productivity and nutrient inputs finding that the distribution of baetids responded to predation pressure with patchy distribution and emigration, and that nutrient inputs that increased algal biomass also increased the number of herbivores, such as baetids. In Topanga Creek, we observed that the shift from baetids to chironomids, although both in the same FFG, was associated with decreased IBI scores, reflecting a less robust BMI community. BMI species can take many years to recover from local extirpation to pre-disturbance levels of multi-age population, suggesting that hydrologic conditions and changes can have population level consequences (Resh et al. 2013). Continued monitoring of the BMI community in Topanga Creek is one of the only ways to identify how the creek food web responds as drought conditions either change or continue.

Despite these fluctuations during the drought, steelhead continue to reproduce and survive throughout Topanga Creek. Their abundance has increased or at least remained steady during the past 14 years. This is in contrast to observations in Malibu Creek, where abundance levels are much more variable, despite the documented influence of anadromous adults in reproduction. Understanding the dynamics of these complex interactions will help inform recovery actions for this endangered species in southern California.

11.5 Summary

Current conditions in Topanga Creek suggest that at this time, the reach most inaccessible to humans at Scratchy Trail is the most functional and that other sample sites downstream of Topanga Bridge reflect more disturbances. It is unclear exactly where the tipping point occurs, but the low flow conditions, combined with the anthropogenic inputs, have resulted in reduced BMI diversity, a shift of BMI community, increases in exotic aquatic species (crayfish and fathead minnow), decreases in egg masses of frogs and newts, and lower numbers of both arroyo chub and steelhead trout.

Topanga Creek is in trouble, although it is still functional enough to support resident steelhead.

As we cannot control the rain or flow, the only positive actions we can take are to

- Reduce nutrient inputs (graywater and septic) into the creek,
- Protect the reach between Owl Falls and Topanga Bridge from increasing rock climbing, hiking and transient activity,
- Reduce impacts from transient encampments, marijuana farms, taggers in the more accessible reach between Topanga Bridge and the ocean.

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12 Best Management Practices (BMP’s)

12.1 Evaluation of BMP's

One of the main efforts of this study was to collect data to monitor current water quality conditions, compare the current levels to previous studies, and identify sources and recommend specific Best Management Practices to reduce, and eliminate if possible, identified contributions to bacteria and nutrient exceedances.

In the 2013-2014 summer dry season a total of 19 exceedances were recorded at Topanga Beach. Since April 2014, there have only been a total of four exceedances, which are potentially tied to the drought conditions.

The Los Angeles Region Sub-watershed Specific Implementation Plan (NSMR 11/4 Bacterial TMDP Implementation Plan 2005) identified target exceedance day reductions for creeks within the Santa Monica Bay watershed as a way of examining watershed specific compliance milestones. Topanga Creek is allowed 17 exceedance days, with a total required day reduction of nine exceedance days. To achieve the target reduction, the Plan recommends a series of Best Management Practices, benefits and performance evaluation measures and methods (Table 12-1).

In addition to the recommendations in the Basin Plan, our results suggest that there are a few specific actions that can be taken to reduce possible sources of FIB at Topanga Beach.

12.2 Recommended BMP’s for Topanga Beach

1) Restore Topanga Lagoon and Lower Topanga Creek State Park. This is a longer-term project, but by restoring natural function to Topanga Lagoon, it would be possible to not only reduce the bacterial sources but also improve habitat for a variety of endangered species, especially tidewater gobies and southern steelhead trout.
2) Continued enforcement of the County code and additional signage may reduce impact and presence of dog feces. The marker data documents a rise in dog associated markers in the winter months when lifeguard supervision and peer-pressure from beach visitors are reduced. During the study, dogs and dog feces, were routinely observed on the beach. The winning student posters have been affixed to the lifeguard station to assist with public outreach.

3) Continue coordinated enforcement to reduce the number of homeless and transients camping in and around the beach and under the PCH underpass. A mass balance calculation of input of one direct deposit to the lagoon (~200g of human feces) was calculated to result in an exceedance of ENT (Riedel et al. 2014 submitted). Direct deposits were observed at both the lagoon and beach on multiple occasions during the study. Direct deposits associated with the transient population is again an enforcement issue but one that could potentially reduce exceedances.
4) Continued maintenance and monitoring of the Lifeguard Station shower and restrooms. Some drainage from the showers directly to the beach was observed on several occasions. When tides are high or storm events shift the lagoon mouth downcoast in front of the building, there is potential for this to become a source.
5) Investigate possible installation and maintenance of culvert filters along Pacific Coast Highway at Topanga Beach to prevent direct road surface run-off spills into Topanga Lagoon.
6) Upgrade the septic systems at the Topanga State Park along PCH as conditions change and opportunities arise. As the lagoon park plan evolves, incorporating state of the art septic systems into any visitor serving facilities is recommended.
7) Increase outreach to commercial facilities that are on septic systems along the beach. The Feed Bin has the last remaining septic system that is connected to a seepage pit. Upgrading that system should be a priority.
8) Additional patrolling of the state park for transient and RV dumping activity could help with any exceedances in the creek, similarly, further enforcement of the no-dogs-allowed-on-beach rule would probably help with the FIB issues at the beach/lagoon.
9) Increase public outreach concerning the problem with dog feces pollution. While changing behaviors is difficult, peer pressure to pick up after your dog, as well as to reduce the number of dogs visiting the beaches could help.
10) Participate in future monitoring and develop funding to initiate a quantitative microbial source identification study to evaluate the potential for developing appropriate site specific objectives.

Table 12-1 Summary of BMP's Benefits and Performance Evaluation Measures for Topanga Lagoon and Creek
(Excerpted from: NSMR 11/4 Bacterial TMDP Implementation Plan 2005)

BMP's and Activities	**Water Quality Benefits**	**Integrated Water Resources Benefits**	**Performance Evaluation Measure and Method**
TMDL Monitoring and studies:	Monitor bacteria, nutrients, metals and organics	N/A	Monitoring results (Note: metals and organics are not being monitored by this study)
Hydrologic Loading Estimates	N/A	Hydrology/ Geomorphology	Study results
Id most relevant Human Health Indicators Study	Bacteria and pathogens	N/A	Study results from this and SIPP
Hydrology vs. Bacteria loading	Bacteria	N/A	Study results from this and SIPP
Bacterial Seasonal Variation Study	Bacteria	N/A	Study results from this and SIPP
Non-Structural Measures:			
Outreach to pet owners (especially dogs on the beach) concerning link between animal wastes and health issues	Bacteria, nutrients and pathogens	N/A	Study results from this and SIPP
Locate areas with corralled animals and educate property owners on bacteria TMDL's	Bacteria and pathogens	N/A	Study results from this and SIPP, Community meetings
Identify horse stables and implement pilot program for manure management	Bacteria and pathogens	N/A	Study results from this and SIPP
Outreach at trailheads encouraging hikers to use restroom facilities	Bacteria and pathogens	N/A	Study results from this and SIPP
Commercial Facilities Control Programs:			
Provide outreach to all commercial facilities with corralled animals	Bacteria and pathogens	N/A	Study results from this and SIPP
Development Planning and Construction Programs:			
Further emphasize applicable existing BMP's in development planning and construction programs	Bacteria, nutrients, metals, organics, pathogens, trash	Water conservation, reuse/recycling, habitat, geomorphology, hydrology, flood volumes	Community meetings to highlight County recommendations
Structural Measures:			
Encourage residential cisterns	Bacteria, nutrients, metals, pathogens,	Water conservation, reuse/recycling,	Community meetings to highlight County

BMP's and Activities	**Water Quality Benefits**	**Integrated Water Resources Benefits**	**Performance Evaluation Measure and Method**
		habitat, geomorphology, hydrology, flood volumes	recommendations
On-site storage and reuse projects	Bacteria, nutrients, metals, organics, pathogens, trash	Water conservation, reuse/recycling, habitat, geomorphology, hydrology, flood volumes	Community meetings to highlight County recommendations
Small scale Infiltration projects	Bacteria, nutrients, metals, organics, pathogens, trash	Water conservation, reuse/recycling, habitat, geomorphology, hydrology, flood volumes	Community meetings to highlight County recommendations

12.3 Recommended Voluntary BMP's for the Topanga Creek Watershed

Although it does not appear that inputs into the upper watershed are associated with the exceedances at Topanga Beach there are indications that they negatively impact the creek's ecosystem. A number of BMP's could be implemented throughout the watershed in order to reduce inputs to the creek and possibly improve overall conditions in Topanga Creek.

1) Establish a community outreach program to inform residents of potential septic system impacts to the creek and encourage them to upgrade their existing septic systems by installation of effluent-filters in septic tank outlets to reduce particulates into leach fields or seepage pits, thus reducing bacterial and nutrient contamination potential. The community outreach program should include identifying funding sources to assist property owners in upgrading their septic systems.
2) Establish a community outreach program to inform residents of potential impacts to the creek from sub-surface and surface graywater discharges.
3) Through community outreach, encourage the installation of additional trash receptacles behind Topanga Market and Abuelita's.

4) Through community outreach, encourage the availability of public restrooms in Topanga Center.
5) Continue coordinated efforts to remove transient encampments and illegal marijuana farms located adjacent to the creek.
6) Implement the Santa Monica Mountains Local Coastal Program policy for existing equestrian facilities to encourage such facilities to come into compliance with all of the LCP policies and regulations as soon as possible.

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13 Recommendations

13.1 Recommendations for Further Study

The intention of this study was to enable the County to understand the sources of bacterial contamination at Topanga Beach, and identify possible ways to eliminate, reduce or mitigate those sources. As with most studies, answering one set of questions leads to more questions. Based on our final results, we would like to suggest several additional studies that would provide more in-depth understanding of this complicated problem, as well as actions that could help the County achieve the Basin Plan targets in the future.

13.1.1 FIB and host associated markers

- Cov- IMS/ATP methods can be used to adaptively track sources in the watershed, furthering our understanding of concentration and dispersal.
- Inv-IMS/ATP Bacteroides method can also be used to adaptively track potential sources of human associated fecal pollution.
- Examine the buoy data to look at the patterns of nearshore flow along Topanga Beach
- What more, if anything, do we need to know in order to identify sources of bacterial contamination?
- Examine ENT speciation when ENT levels are in exceedance at beach and lagoon sites-compare ENT speciation results to marker values for further understanding of sources.
- Further examine relationship between sand/sediment and water FIB and marker levels to better understand if resuspension of FIB/markers is contributing to water column FIB and marker levels. Further examine sediment/sand as potential reservoir for FIB and markers.
- What impacts might Sea Level Rise have on the movement and dilution of FIB between the lagoon and the ocean?
- In collaboration with Dr. Doug Hammond at USC, examine the isotope signatures of water leaching through the sand berm from the lagoon to the ocean to get a better idea of the time lag and potential for filtration.
- Expand field sampling to examine the patterns of gull and dog markers as they travel from the lagoon to the ocean. Examining persistence of these markers in situ in water and sand would allow for a better understanding of these patterns.

- Why does enterococci survive the transition from the lagoon to the ocean in higher concentrations?
- Identify types of bacterial colonies marketed to homeowners to improve their septic function and examine their potential contributions or impacts on FIB found in the creek and lagoon.
- Participate in future monitoring and develop funding to initiate a quantitative microbial source identification study to evaluate the potential for developing appropriate site specific objectives.

13.1.2 *Ecological interactions*

- Develop an ecosystem process model using stable isotopes to examine ecological controls such as nutrient cycling and predation on FIB, benthic macroinvertebrates, diatoms and soft-bodied algae dynamics.
- Compare diatom and soft-bodied algae species abundance, growth patterns and ecological tolerances between Malibu and Topanga, and within a southern California region context (work with Las Virgenes Municipal Water District, Aquatic Bioassay and Consulting Inc., and SCCWRP). Data for 2014 should be available in winter 2015.
- Continue annual stream surveys to track response to drought by BMI, amphibians and fish populations in relation to algae cover and water quality in Topanga Creek.
- Track the presence and abundance of beach wrack (kelp) and sea birds on the berm between Topanga Lagoon and the ocean.
- Continue monitoring and active removal efforts for invasive plants and animals, especially crayfish.

13.1.3 *Best Management Practices and Community Outreach*

- Develop a survey for the community regarding how pet wastes are handled to encourage active management. Conduct active outreach effort to provide information on the effects of dog waste on water quality. The 2014-2015 Watershed Stewards will work on this effort.
- Establish volunteer bird monitoring at Topanga Lagoon and Beach to obtain more information on numbers of birds and use/roosting patterns.
- Find funding to repair the Feed Bin OWTS in Topanga State Park.
- Investigate the correlation between marijuana farms and water quality in Topanga Creek.