

Marina del Rey Harbor Site-Specific Objective Study



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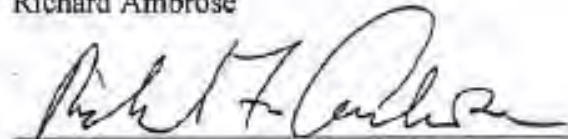
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Reviewed and Approved:

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6-30-21

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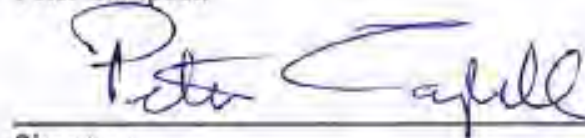


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LIST OF ACRONYMS AND ABBREVIATIONS

BLM	Biotic Ligand Model
CCC	Criterion Continuous Concentration
CIMP	Coordinated Integrated Monitoring Program
CTR	California Toxics Rule
DOC	dissolved organic carbon
EC50	median effective concentration
fWER	final Water-Effect Ratio
LACDBH	Los Angeles County Department of Beaches and Harbors
LACPW	Los Angeles County Public Works
MdR Harbor	Marina del Rey Harbor
µg/L	microgram per liter
mL	milliliter
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RWQCB	Regional Water Quality Control Board
SSO	site-specific objective
sWER	sample Water-Effect Ratio
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
Toxics TMDL	<i>Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor</i>
TBT	Tributyltin
USEPA	U.S. Environmental Protection Agency
WER	Water-Effect Ratio

EXECUTIVE SUMMARY

Copper is a contaminant of concern in Marina del Rey Harbor and was included in the *Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor* (Toxics TMDL; Los Angeles RWQCB/USEPA 2014). Monitoring and special studies in the Harbor have shown that dissolved copper concentrations frequently exceed the chronic (4-day average) criterion (also referred to as Criterion Continuous Concentration [CCC]) of 3.1 micrograms per liter ($\mu\text{g/L}$), as specified in the California Toxics Rule (CTR). A revision to the Toxics TMDL was adopted by the Los Angeles Regional Water Quality Control Board (RWQCB) in February 2014 (Los Angeles RWQCB 2014) and was subsequently approved by the State Water Resources Control Board (SWRCB) in September 2014 (SWRCB 2014). These revisions included dissolved copper load allocations to help address the CTR exceedances in Mdr Harbor. In addition to these changes, the U.S. Environmental Protection Agency (USEPA)-approved Water-Effect Ratio (WER) method may be used to develop site-specific water quality objectives. If adopted by the Los Angeles RWQCB and approved by the SWRCB Office of Administrative Law and USEPA, this new objective will supersede the current CTR CCC criterion as the water quality standard for dissolved copper in Mdr Harbor.

This report summarizes the technical results of the Mdr Harbor Site-Specific Objective (SSO) Study, which used the WER method to evaluate the potential impacts of site-specific conditions on the bioavailability of copper and develop a scientifically defensible copper SSO for Mdr Harbor that remains protective of aquatic life and the beneficial uses. The WER study design was developed in collaboration with the Technical Advisory Committee (TAC) following *The Interim Guidance on Determination and Use of Water-Effect Ratios for Metals* (USEPA 1994) as well as the methods used in two previous surface water WER studies in San Francisco Bay and San Diego Bay (Clean Estuary Partnership 2005; Bosse et al. 2014). Public participation and feedback from stakeholders were solicited during the work plan development and as the study progressed.

The study was designed to capture a range of representative water quality conditions that exist in the Harbor, including factors such as seasonality (e.g., summer vs. winter), stormwater discharge (wet vs. dry weather), and hydrology (tides or depth). It was important to collect samples from a range of conditions as the relative importance of these factors in controlling or influencing bioavailability of copper in Mdr Harbor is not well-known. These factors were incorporated into the sampling plan as six unique sampling events: two winter wet weather events (≥ 0.5 inches rain), two winter dry weather events (spring and neap tides), and two summer dry weather events (spring and neap tides). Additionally, the sampling design included five station locations, covering two back basins, two front basins, and the main channel near the mouth of the Harbor. This design follows the EPA guidance to collect samples from multiple stations distributed over a minimum of three separate sampling events that include different seasons and locations.

In addition to these factors, additional sampling procedures were performed to ensure spatial and tidal representativeness. For all sampling events, the samples from the four basin locations were composites of subsamples collected at the inner, mid, and outer portion of each basin. For the winter and summer dry sampling events, all five stations were sampled twice in one day: once during flood tide and once during ebb tide. These two samples were composited together such

that one final sample per station was collected for each sampling event. This compositing over space (inner, mid, and outer basins) and tide (ebb and flood) was included to increase the representativeness of the data for describing conditions in the Harbor.

For each sampling event, field measurements (pH, temperature, salinity, and dissolved oxygen) were recorded, and water samples were collected for chemistry analysis (total and dissolved metals, dissolved organic carbon) and toxicity testing. The standard 48-hour development toxicity test (USEPA 1995) was performed using *Mytilus galloprovincialis* embryos due to their well-established sensitivity to copper. This species is recommended for WER calculation in the USEPA (1994) Interim Guidance and has been the primary or sole species used for WER development in recent studies in San Francisco Bay (San Francisco Bay RWQCB 2007a) and San Diego Bay (Bosse et al. 2014).

To calculate a WER, the median effective concentration (EC50) values of the site water and a reference water are needed. The reference water for this study was obtained from the Granite Canyon Marine Pollution Studies Laboratory in Monterey, CA, which had low background copper concentrations (0.04-0.41 µg/L). A series of spiked copper treatments were prepared for the reference water (low copper baseline) and the Harbor samples (higher copper baseline) collected from each sampling event to determine the EC50 values. This selection of copper treatments (0 to 23 µg added Cu/L) was designed to produce toxicity results ranging from no effect to complete inhibition of normal embryo development (assuming minimal ambient toxicity). For each sampling event, these EC50 values were used to calculate sample WERs (sWERs) for each station by taking the site water EC50 value divided by the reference water EC50 value (Equation 1):

$$\text{WER} = \frac{\text{EC50 Site water}}{\text{EC50 Reference water}} \quad (1)$$

Overall, the WER study provided chemistry and toxicity data for the Harbor over six events, in addition to the three site characterization events. These results showed dissolved copper concentrations frequently exceeded the current water quality objective (> 3.1 µg/L). The lowest copper concentrations were detected at the main channel station and ranged from 0.82-3.64 µg/L. The copper concentrations in the basins ranged from 5.27 µg/L (Basin F, summer dry, spring tide) to 17.8 µg/L (Basin A, winter dry, spring tide). Comparing each sampling event, WER 2 had the lowest copper concentrations and WER 7 had the highest copper concentrations.

The toxicity test results provided information on ambient toxicity as well as the EC50 values needed for sWER calculation. Site water was not consistently toxic. EC50 values for MdR Harbor ranged from 8.95 µg/L (Basin A duplicate, winter dry, neap tide) to 15.77 µg/L (Basin E, wet weather). The granite Canyon reference water EC50 values ranged from 6.89 µg/L to 10.07 µg/L. Ambient toxicity was observed in WER 6 (winter dry, neap tide) for Basin E, and WER 7 (winter dry, spring tide) for all basin stations. As such, copper-spiked EC50 and sWER values could not be determined for these samples. Toxicity identification evaluation testing was not performed, so no conclusion can be made on the cause of toxicity in these samples, including if the toxicant was copper. Additionally, the main channel (MC3) station during WER 3 (wet weather) was not dosed with high enough copper concentrations to elicit a toxic response greater than 50% abnormal development, so EC50 and sWER values for this sample could not be

calculated. Of the 30 possible sWERS (five stations over six events), 24 were capable of being calculated.

Generally, the highest sWERS were observed in wet weather conditions (1.54-2.04) and the lowest sWERS were observed in dry weather conditions (0.92 to 1.44). These results confirm the site characterization study conclusion that the highest copper bioavailability would occur in dry weather compared to wet weather. Within the dry weather sampling events, the lowest sWERS were observed in winter dry weather (0.92-1.27).

The TAC agreed a single fWER should be calculated for MdR but did not reach consensus on the final WER (fWER) calculation. Instead, the TAC recommended one of two fWERs: (A) a geometric mean of all sWERS (=1.40), or (B) a geometric mean weighted by time in wet versus dry weather conditions (=1.32). Since the lowest sWERS occurred during dry weather, and dry weather comprises over 90% of the year in Los Angeles, the weather-weighted geometric mean is lower than the unweighted geometric mean. The unweighted geometric mean has the greatest sample size (N=24) and is consistent with USEPA guidance and was used in previous fWER calculations for San Francisco Bay and San Diego Bay. The weather-weighted fWER is more representative of the average year-round condition. Without consensus, the TAC left the decision on which fWER to use to the regulated and regulatory stakeholders during implementation phases.

1. INTRODUCTION

1.1 Regulatory Background

In 1998, the back basins of Marina del Rey (MdR) Harbor were placed on the 303(d) list for contaminants impacting sediment, fish tissue, and benthic infauna. At that time, pollutants of concern for sediment included DDT, chlordane, lead, copper, and zinc and pollutants of concern for fish tissue included those for sediment and PCBs, dieldrin, and tributyltin (TBT). However, in 2002, changes were made to the 303(d) list; copper, lead, zinc and TBT in fish tissue, DDT in sediment, and benthic infauna degradation were delisted and PCBs in sediment for MdR back basins were newly listed. Based on the 303(d) list and its subsequent modifications, the MdR Harbor Toxics TMDL was promulgated in 2005 to address impairments associated with sediment for copper, lead, zinc, chlordane, PCBs, and toxicity and fish tissue for DDT, dieldrin, chlordane, PCBs, and fish consumption advisory (Los Angeles RWQCB/USEPA 2005). Monitoring required by the Toxics TMDL have shown that dissolved copper concentrations frequently exceeded the chronic (4-day average) criterion (also referred to as Criterion Continuous Concentration [CCC]) of 3.1 micrograms per liter ($\mu\text{g/L}$), as specified in the California Toxics Rule (CTR).

The Toxics TMDL was revised and adopted by the Los Angeles Regional Water Quality Control Board (RWQCB) in February 2014 (Los Angeles RWQCB 2014) and was subsequently approved by the State Water Resources Control Board (SWRCB) in September 2014 (SWRCB 2014). Toxics TMDL revisions were designed to take into consideration new data on the spatial extent and magnitude of sediment contamination as well as address the dissolved copper CTR exceedances in the water column. As such, the Toxics TMDL includes load allocations for dissolved copper required to ensure that dissolved copper concentrations in MdR Harbor are less than the CCC criterion in the CTR.

In SWRCB Resolution 2014-0049 (SWRCB 2014), the SWRCB recognizes that the U.S. Environmental Protection Agency (USEPA)-approved Water-Effect Ratio (WER) method may be used to derive site-specific water quality objectives (SSOs) and, if adopted by the Los Angeles RWQCB and approved by the SWRCB Office of Administrative Law and USEPA, will supersede the current CTR CCC criterion as the water quality standard for dissolved copper in MdR Harbor. Conditional approval to conduct an SSO study for Marina del Rey Harbor was granted by the Los Angeles RWQCB in September 2017 (revised in June 2018).

1.2 Development of Site-Specific Objectives

Although there are exceedances of the dissolved copper CCC in MdR Harbor, the concentration threshold necessary to protect aquatic life in MdR Harbor is uncertain. It is well known that water quality parameters (e.g., pH, dissolved organic carbon [DOC], and salinity) influence the biological availability of copper in marine water and may reduce the potential to cause toxicity to aquatic life (USEPA 1994; Di Toro et al. 2001). It is possible that site-specific parameters can also lead to an increase in bioavailability/toxicity. As such, a $\text{WER} > 1$ indicates the

environmental conditions reduce toxicity; a WER<1 indicates an increase in toxicity; and a WER=1 indicates no site-specific change to toxicity.

The federal water quality criteria (from which the CTR criteria were derived) for dissolved copper were developed to be conservative to protect marine aquatic life in all waters of the U.S. regardless of site-specific water characteristics. Specifically, water quality criteria were developed based on laboratory studies in which filtered seawater was used, and consequently, these studies do not necessarily account for many of the physical constituents (e.g., pH, DOC, and salinity) that may interfere with the toxicity of potential chemicals of concern, such as copper. Consequently, the USEPA has developed procedures that can be performed to develop water quality criteria that are reflective of site-specific conditions, while still providing the required level of protection for aquatic life.

The current water quality criteria (CCC and CMC) for copper are designed to be protective of the most sensitive species (for copper, this is the mussel, *Mytilus sp.*) as a margin of safety. When the same species is used for a WER to adjust the copper toxicity threshold in the field sample to match the toxicity of copper in laboratory water, the margin of safety intended in the original criteria is maintained. The SSO can be calculated as:

$$\text{SSO} = \text{CCC or CMC} \times \text{WER} \quad (2)$$

The Interim Guidance on Determination and Use of Water-Effect Ratios for Metals (USEPA 1994) provides guidance for determining SSOs. This guidance includes three options: 1) the recalculation procedure; 2) the WER procedure; and 3) the resident species procedure. The recalculation procedure is intended to account for relevant differences between the sensitivities of the aquatic organisms in the national dataset and the sensitivities of organisms that occur at the site. The WER procedure compares the toxicity of copper dissolved in different water types to determine an adjustment factor for the water quality standard. The resident species procedure is intended to account for differences in resident species sensitivity to biological availability and/or toxicity of a material due to variability in physical and chemical characteristics of the site water. In MdR, the WER procedure appears to be the most appropriate if calculated using toxicity tests with the most sensitive resident species in MdR Harbor. There are insufficient new data for the recalculation procedure and there are no threatened or endangered species in MdR, negating the need to account for additional sensitive resident species.

The Biotic Ligand Model (BLM) is another USEPA-approved approach for determining site-specific criteria for dissolved metals in freshwater environments (Di Toro et al. 2001; Santore et al. 2001). A marine version of the BLM is currently under review by the USEPA but has not yet been approved. Nonetheless, some testing in marine environments has been performed to evaluate the BLM's ability to predict toxicity at marine sites throughout the United States (Arnold et al. 2005). Results have shown that the BLM can provide an accurate prediction of copper toxicity to sensitive marine taxa in marine receiving waters and that the BLM-predicted toxicity is strongly correlated with measured toxicity. The BLM approach requires only chemical and physical water quality data (salinity, pH, temperature, and DOC) as inputs and consequently is a more cost-effective and less time-consuming method than the toxicity-based WER. Because of its efficiency, the BLM may allow for the examination of a wider range of site-specific conditions than could be captured during WER studies as well as evaluation of effectiveness of

various management strategies. As such, the BLM can be used as a tool to provide additional data interpretation and comparison to the toxicity-based WER results. Ultimately, any proposed SSO will be based on the toxicity-based WER data alone.

1.3 Study Objective

The objective of this study was to develop a scientifically defensible WER for Mdr Harbor that accounts for site-specific conditions and is as protective of aquatic life and the beneficial uses of Mdr Harbor as the current criteria.

In this study, the WER procedure that was consistent with the USEPA (1994) Interim Guidance was used for Mdr Harbor using *Mytilus* sp. to ensure the WER is scientifically defensible and protective of beneficial uses. Data to support the BLM was collected and a BLM-based WER was calculated for contextual understanding and insight for final WER selection, but the primary focus was the toxicity-based WER.

2. STUDY DESIGN AND FIELD SAMPLING METHODS

The WER study design was developed based on the USEPA (1994) Interim Guidance for determining water effects ratios for metals. The guidance for development of WERs for surface waters (e.g., bays and harbors) located away from effluent plumes (Method 2) provides primarily qualitative descriptions and recommendations to guide the investigator in developing the specifics of the study, rather than specific details.

To bolster the scientific integrity of this study, a technical advisory committee (TAC) was established to provide more thorough scientific review and guidance for the development and implementation of this SSO study (SCCWRP and Latitude Environmental 2019). To reduce the lead agency's bias towards study methods and interpretation of results, the TAC members were selected in consultation with the Los Angeles RWQCB and non-governmental organizations (LA Waterkeeper and Heal the Bay). The TAC was composed of three internationally recognized leaders in toxicology and WERs (Table 1). The TAC was responsible for providing an independent review of the study design, study results, and final report.

In addition to requesting the feedback and expert advice from the TAC, public participation was supported and encouraged throughout this study. This process included a period of public review of the draft Workplan as well as participation during the Workplan review workshop with the TAC in December 2018. Additionally, TAC meetings were held periodically during this study (2019-2021) to review the results of the WER sampling events. These webinar-style meetings were open to the public and advertised by the Regional Board. Participants could provide comments or questions during the meeting.

Table 1. Technical Advisory Committee Members.

Name	Affiliation	Expertise
Peter Campbell	University of Quebec, INRS, Quebec, Canada	Trace metal analysis, speciation, toxicology, bioaccumulation
Gary Cherr	Bodega Marine Laboratory, University of California, Davis, CA	Reproductive physiology, developmental biology, biochemistry, environmental toxicology
Richard F. Ambrose	University of California, Los Angeles, CA	Assessment, restoration, and remediation of coastal habitats, including wetlands and rocky intertidal. Climate change impact assessment and mitigation

The USEPA (1994) Interim Guidance recommends that WER analyses be conducted over a range of conditions so that the results are representative of the variations in water quality at the site. The guidance also states that the study should include multiple stations distributed over a minimum of three separate sampling events that include different seasons and locations. Potential sources of variability include seasonality (e.g., summer vs. winter), stormwater discharge, hydrology (tides or depth), and episodic events (e.g., plankton blooms and harbor activities). The relative importance of these factors in controlling or influencing bioavailability of copper in Mdr Harbor was investigated in a site characterization study conducted in 2018. The results of the site characterization study (Appendix A) were used to develop the final WER study design.

2.1 Sampling Design and Station Locations

Six sampling events were proposed and completed for the WER study (Table 2). These events were distributed over an approximately 16-month period to cover major seasonal, weather, spatial, and tidal variations. Four of the six sampling events occurred during dry weather (winter and summer dry), when the DOC concentration was expected to be lowest, resulting in higher copper bioavailability. The remaining two events were wet weather events, which required at least 0.5 inches of rain in the preceding 24 hours and the samples had to be collected within 24 hours from the end of the storm.

To ensure spatial representativeness, samples were collected from five stations: two front basins (A and B), two back basins (E and F), and one main channel location (MC3). The samples collected from the four basin locations were made up of composites of the inner, mid, and outer portions of the basin (Figure 1). For example, three samples were collected and pooled together from MdrH-A (e.g., A-1: inner, A-2: mid, and A-3: outer). All samples for all events were collected at 1 m below the water surface.

To ensure temporal representativeness, samples were collected during different tidal conditions. On the day of sampling, samples were collected during flood tide and again at ebb tide. These two samples were collected on the same day approximately six hours apart and were composited together such that one final sample per station was collected for chemical and toxicity analysis. To ensure temporal representativeness of differing tidal regimes, dry weather sampling events were conducted during spring tides (high variation between low and high tide) and neap tides

(low difference between low and high tide). These two sampling events were not composited together and occurred approximately one month apart.

Table 2. Water-effect ratio sampling event matrix.

Event	Sampling Date	Tide Type		Summer	Winter	
				Dry Weather	Dry Weather	Wet Weather
		Spring	Neap	April – October	November – March	November – March
1	August 26, 2019		X	X		
2	October 1, 2019	X		X		
3	December 5, 2019	NA	NA			X
5	March 13, 2020	NA	NA			X
6	November 10, 2020		X		X	
7	December 10, 2020	X			X	

Notes:

Wet weather sampling is not dependent on tide type.

Event 4 failed several toxicity and chemistry QA/QC measures and was excluded upon recommendation by the TAC.

NA = not applicable

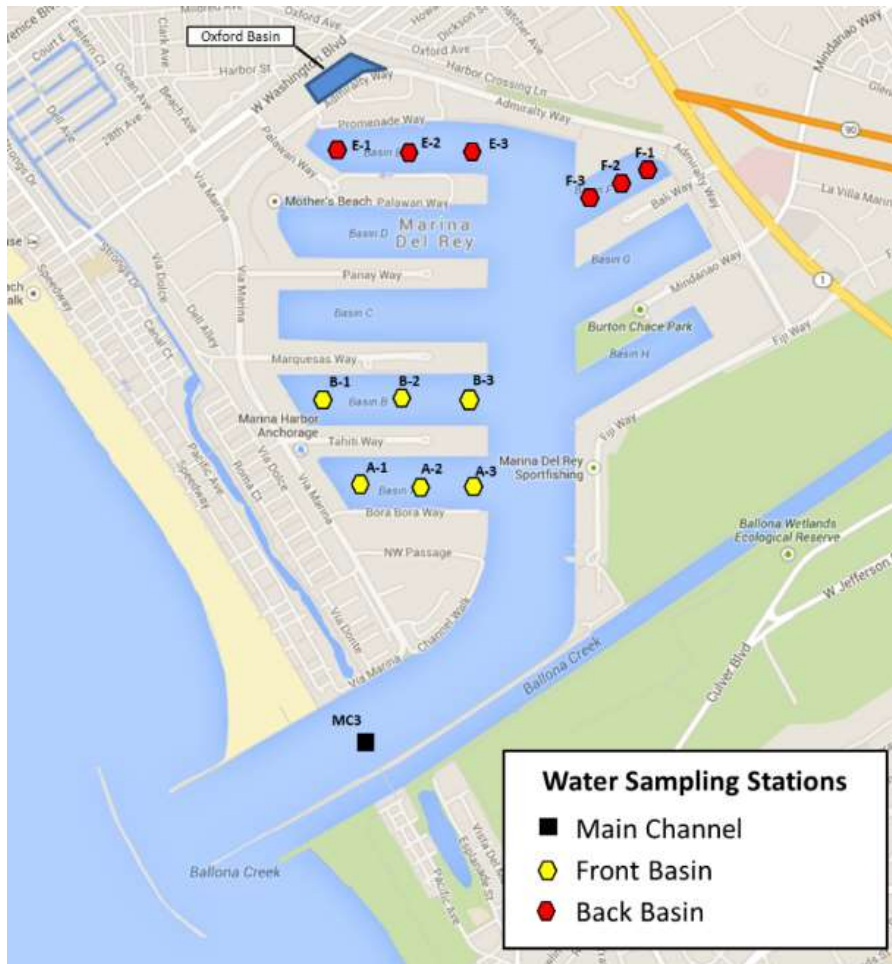


Figure 1. Stations for WER analysis.

2.2 Sample Collection and Processing

Detailed methods for water sample collection and processing are described in the Workplan (Appendix B; SCCWRP and Latitude Environmental 2019). Briefly, a peristaltic pump fitted with Teflon-lined tubing was used to collect water samples and fill HDPE bottles. The tubing and sample collection bottles were rinsed with site water prior to sample collection. For dry weather sampling, each station was sampled twice, once during the ebb tide and once during the flood tide. During each sample collection time, one 2-L HDPE bottle was collected for each station: one 2-L bottle was filled completely for MC3, and one 2-L bottle was filled proportionally (one-third) with each basin subsample (inner, mid, and outer). These samples were stored on ice until sample collection was complete. Each set of a station's two 2-L bottles were combined at the end of the sampling day and mixed prior to subsample collection for DOC and metals analysis. For wet weather sampling, each station was sampled once within 48 hours after a significant storm: for the MC3 station, one 1-gallon HDPE bottle was filled; for the basin locations, one 1-gallon bottle was filled one-third with each basin subsample (inner, mid, and outer).

Subsamples of the daily composite samples for DOC and metals analysis were taken after all water samples were collected and composited for the day. DOC and dissolved metal samples were filtered using plastic syringes fitted with 0.45-micron filters. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new clean filter was used for each sample and analysis type and the same pre-rinsing technique was applied. A “clean hands/dirty hands” technique was employed during sampling and filtering to prevent sample contamination. This technique designates one person as “clean hands” who handles the clean subsample container and filtration supplies, and one person as “dirty hands” who handles the “dirty” composite sample container and opens the exterior bag for the subsample supplies. More details are provided in the Workplan and QAPP (Appendix B). The remaining sample was stored in the 1-gallon bottles and saved for toxicity testing. A list of sample volumes and containers is provided in Table 3.

Table 3. Volumes and containers for field samples.

Analysis Type	Volume (mL)	Container Type/Size
Dissolved organic carbon	40	Pre-combusted glass vial
Dissolved metals	50	Polypropylene tube
Total metals	50	Polypropylene tube
Toxicity	3,785	HDPE bottle

Note: mL = milliliters

In addition to the field samples, multiple quality assurance (QA) samples were collected and processed in the field, including a travel blank, field blank, field duplicate, and matrix spike (Table 4). One of each QA sample type was collected during each sampling event. All the blank samples used the blank laboratory water provided by Physis Environmental Laboratories, Inc. The travel blank was opened during sample processing for one station and was analyzed for total metals. The field blank was treated as if it were a field-collected sample and went through the process of filtration and subsample collection using the containers listed in Table 7 for DOC, and total and dissolved metals. The tubing blank was collected the day before field sampling. The blank water was run through the clean tubing and collected in a clean 1-L HDPE bottle prior to filtration and subsample collection for DOC, and total and dissolved metals. A field duplicate was collected from one station during each sampling event to test the precision of sample collection. Extra sample was collected to provide a matrix spike sample for total and dissolved metals for all sampling events. A matrix spike was added for DOC analysis starting with WER 5. A DOC certified reference material (CRM) was analyzed with every batch of DOC samples.

Table 4. Description of quality assurance sample types for field sampling.

Sample Type	DOC Volume (mL)	Total Metals (mL)	Dissolved Metals (mL)
Travel Blank	--	50	--
Field Blank	40	50	50
Field Duplicate	40	50	50
Matrix Spike	40*	50	50
Tubing Blank	40	50	50

Notes:

DOC = dissolved organic carbon

mL = milliliters

*DOC matrix spike sample was collected and analyzed for WER events 5, 6, and 7.

2.3 Parameters and Analysis Methods

The full list of parameters analyzed can be found in Table 5.

Several water quality parameters (e.g., pH, temperature, dissolved oxygen, and salinity) were measured using probes (YSI Pro1020 and 35) in the field at the time of water sampling. These probes were calibrated prior to each sampling event.

Laboratory analysis focused on DOC, metals, and toxicity. Concentrations of both copper and zinc were measured, as both metals may be elevated in harbors and contribute to ambient toxicity. Zinc concentrations in Mdr Harbor were not expected to exceed water quality standards but were considered as a possible partial contributor to Harbor water toxicity. Toxicity methods are detailed in Section 3.0.

In addition to the quantitative analysis of DOC, a subsample (5-10 mL) of the filtrate was taken prior to sample acidification for qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340 nm (SAC340), which is an indicator of DOC aromaticity (Equation 3; Tait et al. 2016). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Research by Al-Reasi et al. (2012) suggests SAC340 values range from 4-15 for microbially-derived DOC, and 28-40 for terrestrially-derived DOC.

$$SAC_{340} = 2303 (Abs_{340}/DOC) \quad (3)$$

where Abs_{340} is the sample absorbance at 340 nm and DOC is the concentration in mg/L.

Detailed methods for chemical analysis are described in the study QAPP (Appendix B; SCCWRP and Latitude Environmental 2019). The methods were selected to provide reporting limits below the levels expected in MdrRH (Table 5). Metal analysis was conducted by Physis Environmental Laboratories, Inc. according to USEPA Method 1640 for trace elements in water, using inductively coupled plasma mass spectrometry. In this procedure, trace elements are pre-concentrated based on their reductive precipitation by sodium tetrahydroborate; iron and palladium are added to samples to aid co-precipitation of metal borides and to enhance the precipitation of metals coming out in the elemental form.

Table 5. Chemistry and toxicity analysis methods and reporting limits.

Analyte	Occasion of Measurement		Analysis Method	Method Detection Limit (µg/L)		Reporting Limit (µg/L)	
	Field	Laboratory		Total	Dissolved	Total	Dissolved
pH	X		Probe	NA	NA	NA	NA
Temperature	X		Probe	NA	NA	NA	NA
Salinity	X		Probe	NA	NA	NA	NA
Dissolved Oxygen	X		Probe	NA	NA	NA	NA
Dissolved Organic Carbon ¹		X	USEPA 9060a	NA	55	NA	55
Copper		X	USEPA 1640 – FePd	0.025	0.005	0.025	0.15
Zinc		X	USEPA 1640 – FePd	0.025	0.025	0.025	0.15
Toxicity		X	USEPA 1995	NA	NA	NA	NA

Notes:

µg/L = micrograms per Liter

NA = not applicable

¹ DOC characterization by spectrophotometry was conducted on selected samples.

Dissolved organic carbon was analyzed at SCCWRP for most of the WER sampling events. Weck Laboratories, Inc. provided analysis support for WER 3 samples during October 2019 when the SCCWRP lab was undergoing renovations. Both laboratories used EPA Method 9060a for the analysis of total organic carbon by combustion or oxidation. With this method, organic carbon in a sample is converted to carbon dioxide by catalytic combustion or wet chemical oxidation. The carbon dioxide formed can be measured directly by an infrared detector or converted to methane and measured by a flame ionization detector. The amount of carbon dioxide or methane is directly proportional to the concentration of carbonaceous material in the sample.

3. TOXICITY TESTING AND LABORATORY METHODS

3.1 Toxicity Test Species and Test Method

Toxicity tests were conducted using *Mytilus galloprovincialis* embryos. This species is recommended for WER calculation in the USEPA (1994) Interim Guidance and has been the primary or sole species used for WER development in recent studies in San Francisco Bay (San Francisco Bay RWQCB 2007a) and San Diego Bay (Bosse et al. 2014). *M. galloprovincialis* is an ideal organism for use in WER copper studies because of its sensitivity to copper and commercial importance. When deriving a site-specific criterion, it is desirable to use a test species whose sensitivity is near the Final Acute Value (FAV). Mussels, *Mytilus sp.* (multiple species), are the most sensitive marine species listed by EPA, with a species mean acute value (SMAV) = 6.19 µg/L. The sensitivity of *M. galloprovincialis* embryo development to copper is similar to that of *Mytilus sp.* The average EC50 for *M. galloprovincialis* from the three Site Characterization study events was 8.12 µg/L. Use of *M. galloprovincialis* helps provide a margin of safety for SSO development for two reasons:

- The current CTR criterion for copper is determined exclusively by *Mytilus sp.*, a grouping that includes *M. galloprovincialis*, for protection of this commercially important species group. Using this species in the Mdr Harbor SSO study will help ensure that the same level of protection is maintained.
- Mussels, including the resident species *M. galloprovincialis*, represent the most sensitive genus in the national saltwater copper toxicity database. They are not only a good surrogate for invertebrate species in general (which tend to be more sensitive to copper than vertebrates) and mollusks (a phylum sensitive to copper; the third, fourth, and sixth most sensitive species in the national copper database are mollusks), but also it is a good surrogate for other sensitive saltwater aquatic animals. The TAC agreed that *M. galloprovincialis* is both appropriate and sufficient for the WER toxicity tests.

Site water and laboratory control seawater toxicity were measured using a 48-hour exposure of mussel embryos under standard conditions as described by USEPA (1995). Test conditions are summarized in Table 6 and detailed methods are described in the study workplan (SCCWRP and Latitude Environmental 2019). Control seawater was obtained from a reference site in Granite Canyon, California, and filtered (0.45 micron) prior to use to remove resident organisms and particulate organic material. This reference site has been used for control water in previous WER studies in San Francisco Bay and San Diego Bay due to its previously reported acceptability for embryo-larval development tests and relatively low DOC content. Toxicity tests were initiated within 36 hours of sample collection. Each sample/treatment was tested using five replicates. For each replicate, approximately 250 *M. galloprovincialis* embryos were exposed in 10 mL of sample for 48 hours. Samples of each treatment were collected for dissolved copper analysis at the beginning (Day 0) and end (Day 2) of the exposure period to confirm the exposure concentration.

Embryos were preserved for examination at the end of the exposure period. The preserved samples were examined using a microscope to determine the numbers of normal and abnormal surviving embryos (Figure 2). The percent of normal embryos was calculated from the count.

Key water quality parameters (dissolved oxygen, pH, salinity, and temperature) and control performance were evaluated to assess test batch acceptability and organism condition. The salinity range was adjusted from 30 ± 2 g/kg (USEPA guidance) to 32 ± 2 g/kg to reflect the local environmental conditions and reduce the need to dilute the site water to adjust salinity, which would alter the DOC and copper concentrations. The test was considered acceptable if three criteria were met: 1) mean normal development in the controls was at least 90%; 2) mean survival in the controls was greater than 50%; and 3) the percent minimum significant difference was less than 25%.



Figure 2. Normally developed (left) and abnormal mussel embryos (images courtesy of Sanitation Districts of Los Angeles County).

Table 6. Summary of test conditions for the 48-hour mussel embryo development test.

Test Species	<i>Mytilus galloprovincialis</i>
Test Procedures	USEPA/600/R-95/136
Age/Size Class	Embryo
Endpoint	Normality of development and survival
Test Type/Duration	Acute static non-renewal/48 hours
Sample Storage Conditions	4°C, dark, minimal head space
Holding Time	≤ 36 hours
Control	Filtered natural seawater (from Granite Canyon, California)
Salinity Adjustment	Hypersaline brine ¹
Water Quality Parameters	Temperature 15 ± 1°C; Dissolved oxygen ≥ 4.0 mg/L
	Salinity 32 ± 2 g/kg; pH 7.5 to 8.3
Photoperiod	16 hours light, 8 hours dark
Test Chamber	22 mL glass shell vials
Replicates/Sample	5
No. of Organisms/Replicate	250
Exposure Volume	10 mL
Aeration/water renewal	None
Feeding	None
Reference Toxicant	Copper chloride
Test Acceptability Criteria	Control mean normal development ² ≥ 90%
	Control mean survival > 50%
	Percent minimum significant difference < 25%

Notes:

g/kg = grams per kilogram; mg/L = milligrams per liter; mL = milliliters

USEPA = U.S. Environmental Protection Agency

¹ No salinity adjustments were needed for this study

² Applied to surviving control embryos

3.2 Dose-Response Testing and EC50 Calculation

Immediately upon return to the laboratory, field water samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper designed to produce toxicity results ranging from no effect to complete inhibition of normal embryo development

(assuming minimal ambient toxicity). An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 7). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. Each treatment group was tested and evaluated using the method described in Section 3.1. Copper EC50 values (concentration causing 50% reduction in percent normal-alive) were calculated using the Trimmed Spearman-Kärber method in CETIS (v1.9.0.8) and were expressed in terms of measured Day 0 dissolved copper concentration.

Table 7. Nominal added copper dose-response concentrations.

Granite Canyon and MC3 samples (µg/L)	Basin Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

3.3 WER Calculation

The USEPA recommends calculating a WER to account for site-specific bioavailability and toxicity of contaminants (USEPA 1994). As part of this WER study, two side-by-side toxicity tests were conducted: one test using the Granite Canyon reference water and the other test using the water samples from MdrH. The WER was determined by calculating the ratio of the median effective concentration (EC50) values from the two tests as shown in Equation 1:

$$\text{WER} = \frac{\text{EC50 Site water}}{\text{EC50 Reference water}} \quad (1)$$

Each sampling event resulted in one sample WER (sWER) per station. When a field duplicate was taken at a station, the average of the two WER values was reported as the single WER result for that station.

The final WER (fWER) was calculated using two methods: the geometric mean of the data from all sampling events (unweighted, Equation 4), and a weighted geometric mean of the data based

on the typical number of wet and dry weather days in Southern California (weather-weighted, Equation 5). For the weather-weighted geometric mean, there are a few options for determining the weights. For example, one could use the average number of rain days per year, which is roughly 34 days in the Los Angeles area. Another approach could mirror this study’s sampling plan which was to collect wet weather samples within 24 hours after a rain event, or a wet weather day plus one day, which would be up to 68 days per year. To calculate the weather weighted geometric mean, the log of the dry weather sWERS were averaged and multiplied by 297 dry days, and the log of the wet weather sWERS were averaged and multiplied by 68 dry days. These two numbers were added together and divided by 365 total days. The antilog was taken to determine the weather-weighted fWER.

$$\text{Unweighted fWER} = 10^{\frac{\sum \log_{10} \text{sWERS}}{n}} \quad (4)$$

Weather-weighted fWER =

$$10^{\frac{\left(\frac{\sum \log_{10} \text{Dry weather sWERS}}{n_{\text{Dry}}}\right)(\# \text{dry days}) + \left(\frac{\sum \log_{10} \text{Wet weather sWERS}}{n_{\text{Wet}}}\right)(\# \text{wet days})}{365}} \quad (5)$$

Where nDry and nWet are the number of dry weather and wet weather sWERS, respectively. The number of dry weather days (#dry days) and the number of wet weather days (#wet days) should add up to the total number of days in a year (365).

3.4 Biotic Ligand Model Analysis

The BLM is a chemical speciation model that can be used to predict metal speciation, complexation, and toxicity to aquatic organisms using site-specific water characteristics (Di Toro et al. 2001; Santore et al. 2001). The BLM is based on the premise that both metal–ligand binding and metal interaction with competing cations may affect toxicity (Di Toro et al. 2001). Thus, the degree of toxicity is expected to be related to the amount of metal available to bind to the biotic ligand, the concentration of other aqueous ligands such as organic matter that can bind up the metal of concern, and the availability of other cations (i.e., calcium), which may have a protective effect. For this study, the marine BLM for copper in saltwater developed by Robert Santore (Version 3.16.2.41 from Windward Environmental, LLC) was used. This model is under review for use by the USEPA in setting water quality criteria in marine systems. Previous research provides a more in-depth description of the model parameters and equations, and its applications to both freshwater and marine systems (Di Toro et al. 2001; Santore et al. 2001; Arnold et al. 2005; Chadwick et al. 2008).

For this study, the BLM was not used in the same way it would be for calculating a new water quality criterion for copper. Instead, the model was run in “Toxicity Prediction Mode”, which calculates an intermediate value that represents the predicted EC50 value (EC50_{BLM}) for a sample based on its salinity, temperature, pH and DOC values (USEPA 2016a). This method was discussed and approved by both the model developer and the TAC. The predicted EC50 values

generated by the model were used to calculate a BLM-predicted WER, defined as the site water $EC50_{BLM}$ divided by the control water $EC50_{BLM}$, as shown in Equation 6:

$$\text{BLM-based WER} = \frac{\text{BLM-predicted EC50 Site Water}}{\text{BLM-predicted EC50 Control or Reference Water}} \quad (6)$$

For this study, the DOC concentration from the measured field sample and the Day 2 toxicity water quality measurements (i.e., pH, temperature, and salinity) were used as the BLM input values.

4. QUALITY ASSURANCE AND QUALITY CONTROL

The field sampling and data review and analysis procedures followed the quality assurance (QA) and quality control (QC) process detailed in the study workplan and QAPP. Field and laboratory blanks, matrix spikes, duplicates and reference materials were analyzed during each sampling event. These results are summarized in the sampling reports (Appendix C). The TAC members discussed any deviations and provided recommendations on the use of the data or any necessary actions before the next sampling event.

4.1 Minor Deviations

The deviations described in this section were reviewed by the TAC and were determined to be minor and the data was acceptable for use.

The results from WER sampling events 1-3, and 5-7 were deemed acceptable with minor deviations. Dissolved copper was detected in field or tubing blanks in WER events 2 and 7, but these values (0.02-0.28 $\mu\text{g/L}$) were at least two orders of magnitude lower than the field samples. A certified reference material for DOC was analyzed during each sampling event, and the expected value range was 0.85-0.90 mg/L . The CRM was measured within range for WER events 1, 3, and 5 (0.86-0.87 mg/L), below range for WER 7 (0.80 mg/L), and above range for WERs 2 and 6 (0.96-0.98 mg/L). A DOC matrix spike sample was analyzed for WER events 5-7. The recovery was acceptable for WERs 5 and 7 with values of 102% and 110%, respectively. For WER 6, the matrix spike of the lab blank was 55% of the spike value, and the matrix spike of the field sample was 436% of the spike value. After following the QAPP actions associated with this deviation, including re-analysis of the spiked samples, the analysts deduced that improper spiking occurred. Unfortunately, there was no additional sample water for creating new spiked samples, but blank spikes in the runs prior to and after this batch met data quality objectives. Overall, the TAC determined the DOC results to be acceptable and valid.

In addition to the water samples, field measurements of pH, temperature, salinity, and dissolved oxygen were measured. All field probes were calibrated and checked prior to each sampling event according to the methods and QA verification sheet outlined in the QAPP. In WER event 3, the salinity probe failed during the sample collection at the final station, Basin F, resulting in no salinity field measurement for that location. Attempts to repair the probe in the field were

unsuccessful. Therefore, salinity samples were returned to the laboratory for analysis. This deficiency did not materially affect the outcome of the study. Overall, the TAC determined the water quality results to be acceptable and valid.

The test acceptability criteria for the mussel embryo development test require a control mean survival of at least 50%, percent normal development of at least 90%, and a percent minimum significant difference (PMSD) of less than 25%. All three toxicity test acceptability criteria were met for WERs 1, 2, 3 and 6. For WER 5, the percent normal development was 79% for the Granite Canyon control, which failed the test acceptability criteria. One of the five replicates was determined to be a statistical outlier and visual observations in the data sheets noted this replicate sample had more debris compared to the other replicates, indicating a likely anomaly due to potential contamination in that test vial. With the statistical outlier removed, the control passed the test acceptability criteria with an average of 93% normal development and a standard deviation of 0.7%. The SCCWRP laboratory seawater, while not the official control, exhibited an average of 94% normal development and a standard deviation of 1.3% in the five replicates. These results were presented to the TAC and the decision was made to exclude the one control replicate. For WER 7, the PMSD was 31% for the Granite Canyon control, which failed the test acceptability criteria. This was likely due to the high variability observed in a few of the spiked treatment groups. Overall, the TAC determined the toxicity test results for WERs 1-3 and 5-7 to be acceptable and valid.

In addition to the toxicity test method quality assurance and quality control procedures, an interlaboratory comparison was performed using the Granite Canyon control water. For the first WER event of the study, two laboratories (SCCWRP and EcoAnalysts, Inc.) performed the copper dose-response toxicity test using the Granite Canyon reference water. The reference water was sent directly from the Granite Canyon laboratory to each participant. SCCWRP made up the copper stock solution and sent a split sample with the spiking protocol to EcoAnalysts for use in their toxicity test. This ensured the same materials and methods were used. Additionally, EcoAnalysts ordered two batches of mussels from Taylor Shellfish Farms and sent one to SCCWRP to minimize organism variability. The dose response curves indicated a slightly higher EC50 for the Granite Canyon water test by EcoAnalysts (11.66 µg/L) compared to SCCWRP (9.50 µg/L). The TAC felt this difference was similar to within-laboratory variability between tests based on laboratory control charts and EC50 values from the literature. SCCWRP's copper reference toxicant test results from 2005 through 2018 resulted in EC50 values ranging from 5.80 µg/L to 11.26 µg/L with a mean of 8.3 µg/L. Copper reference toxicant tests performed at EcoAnalysts from 2007 through 2011 resulted in EC50 values ranging from 3.68 µg/L to 14.05 µg/L with a mean of 9.92 µg/L. Additionally, the EC50 data for *Mytilus spp.* cited in the USEPA's 2003 Draft Update of Ambient Water Quality Criteria for Copper, ranged from 3.75 µg/L to 14.1 µg/L (Table 1b of the 2003 USEPA document). The EC50 data for *Mytilus galloprovincialis* cited in the USEPA's 2016 Draft Aquatic Life Ambient Estuarine/Marine Water Quality Criteria for Copper, ranged from 3.56 µg/L to 59.4 µg/L (Table A-1 of the 2016 USEPA document). Overall, the TAC determined SCCWRP's reference toxicant test results were comparable to both historical values as well as the results by EcoAnalysts.

4.2 Major Deviations

The deviations described in this section were reviewed by the TAC and were determined to be major and the data was not acceptable for use.

The TAC reviewed the preliminary results from WER event 4 (Appendix C-4) and determined there were too many quality assurance deviations for the toxicity testing and chemical analyses, and recommended these results be excluded. Toxicity test quality assurance deviations included low negative control survivorship across all replicates, ultimately failing to pass test acceptability criteria. Increased replicate variability was also observed, which supported evidence of sub-optimal test organism condition. Additionally, dissolved copper concentrations were observed in the equipment and field blanks (0.55-0.94 µg/L), the DOC CRM was below the acceptable range, and non-monotonic dissolved copper concentrations were observed in sample MdrRH-B for Day 0. The combination of these deviations resulted in the recommendation to re-sample for the winter dry weather event. To help resolve the chemistry deviations, cleaning protocols were reviewed and updated, including additional technician training, and blank and CRM testing was continued for the remaining sampling events.

5. SAMPLING AND WATER QUALITY RESULTS

5.1 Sampling Events

The six WER sampling events encompassed several conditions, including season (winter and summer), weather (wet and dry), and tidal cycle (spring and neap). Figure 3 illustrates the sample collection times for each sampling event relative to tide height on that day. WERs 1 and 2 represent the summer dry weather, neap and spring tides, respectively. The samples for WER 1 were collected over a + 3.01 ft sampling window, and the samples for WER 2 were collected over a + 3.65 ft sampling window. WERs 6 and 7 represent the winter dry weather, neap and spring tides, respectively. The samples for WER 6 were collected over a + 2.21 ft sampling window, and the samples for WER 7 were collected over a + 4.42 ft sampling window. Tide height was based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day, and these data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>).

WERs 3 and 5 represent the two wet weather sampling events. WER 3 samples were collected on December 5, 2019 after 1.15 inches of rain the day before. This storm occurred five days after a storm from November 27-29 which produced 1.33 inches of rain. For the WER 5 event, a storm on March 12-13, 2020 produced approximately 1.99 inches of rain prior to sampling and after a dry antecedent period of two days. This storm continued to produce small amounts of rain through March 16th, resulting in an additional 0.58 inches of rain over the three days following sampling. The previous rain event on March 10th produced 0.18 inches of rain, which was not enough to meet the wet weather trigger. Prior to March 10, 0.03 inches of rain was observed on January 21, 2020, and 0.44 inches of rain was observed from January 16-17. The rainfall data were obtained from the Los Angeles County Public Works precipitation map and rain gauge data

website (<https://dpw.lacounty.gov/wrd/rainfall/>). The Ballona Creek rain gauge provided the closest location to the Harbor.

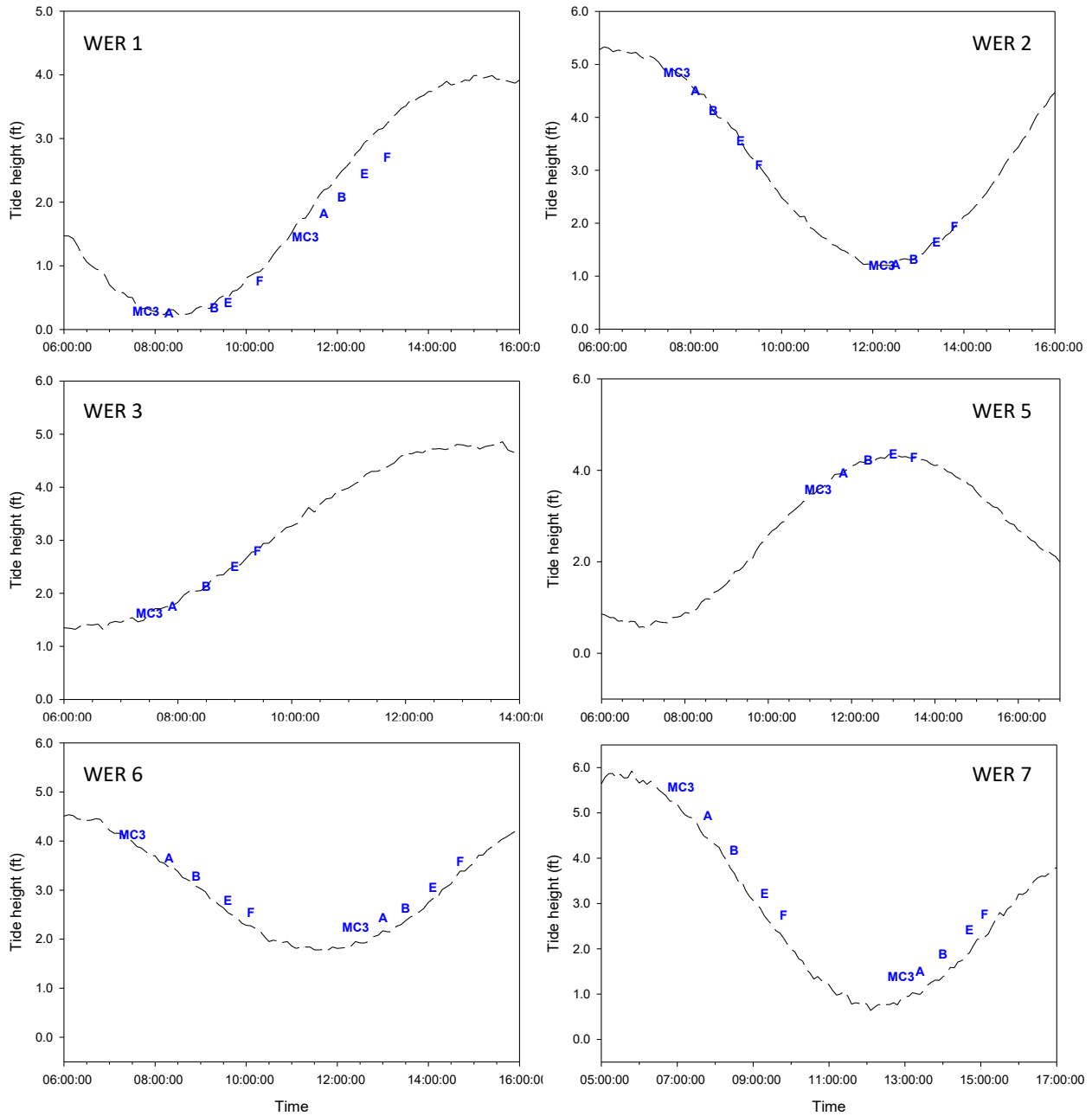


Figure 3. WER sample collection times relative to tide height. WERs 1 and 2 were the summer, dry weather neap and spring tide events, respectively. WERs 3 and 5 were the wet weather events. WERs 6 and 7 were the winter, dry weather neap and spring tide events, respectively.

5.2 Water Quality Results

Water quality measurements were taken during each sampling event as well as during the toxicity test setup and breakdown (Day 0 and Day 2). For the field measurements (Table 8), pH ranged from 7.49-8.16, with higher pH typically measured at the MC3 station. Water temperatures ranged from 14.7-25.5°C and were highest in the summer dry weather events. Salinity in the Harbor ranged from 28.4-35.1 ppt, with dry weather ranging from 33.3-35.1 ppt, and wet weather ranging from 28.4-32.7 ppt. Dissolved oxygen concentrations ranged from 5.65-8.68 mg/L.

Table 8. Average water quality data (pH, temperature, salinity, and dissolved oxygen) for each station during each sampling event.

Measure	Station	WER 1 (Summer dry, neap)	WER 2 (Summer dry, spring)	WER 3 (Wet)	WER 5 (Wet)	WER 6 (Winter dry, neap)	WER 7 (Winter dry, spring)
pH	MdRH-MC3	8.16	8.16	8.29	8.06	7.66	7.95
	MdRH-A	8.06	8.07	8.03	7.94	7.62	7.83
	MdRH-B	8.08	8.06	8.04	7.90	7.56	7.81
	MdRH-E	8.08	7.98	7.98	7.84	7.49	7.81
	MdRH-F	8.06	8.09	8.02	7.82	7.53	7.78
Temperature (°C)	MdRH-MC3	23.5	20.5	15.1	15.9	15.5	14.7
	MdRH-A	24.6	21.9	15.9	16.7	16.5	14.8
	MdRH-B	25.3	22.2	16.1	16.8	16.9	14.9
	MdRH-E	25.3	23.1	16.6	17.4	17.5	15.3
	MdRH-F	25.5	22.6	16.3	18.2	17.2	15.4
Salinity (ppt)	MdRH-MC3	34.0	33.3	32.1	32.1	34.7	34.2
	MdRH-A	34.4	33.5	31.6	32.7	34.9	34.0
	MdRH-B	34.2	33.5	30.9	31.9	35.0	34.0

Measure	Station	WER 1 (Summer dry, neap)	WER 2 (Summer dry, spring)	WER 3 (Wet)	WER 5 (Wet)	WER 6 (Winter dry, neap)	WER 7 (Winter dry, spring)
	MdRH-E	34.1	33.4	31.7	29.0	35.1	33.6
	MdRH-F	34.1	33.5	30.4	28.4	34.9	33.8
Dissolved Oxygen (mg/L)	MdRH- MC3	7.38	7.48	7.73	8.66	6.91	6.95
	MdRH-A	6.65	6.30	6.65	8.20	6.73	6.59
	MdRH-B	6.70	6.21	6.60	7.08	6.48	6.54
	MdRH-E	6.75	5.65	6.34	8.68	6.10	6.92
	MdRH-F	6.63	6.49	6.38	6.76	6.38	6.72

Note: These are the average values of the individual raw data collected on each sample date. The field duplicates were included in the raw data used for averaging. For raw data, please see sampling summary reports in Appendix C.

Day 2 toxicity test water quality measurements were used for the BLM analysis as it most closely matched the conditions experienced by the mussel embryos (Table 9). For that reason, the temperature values reflected the more controlled toxicity test conditions and ranged from 14.9-17.6°C. Test sample pH ranged from 7.82-8.09, and salinity ranged from 31.2-34.9 ppt. The lowest toxicity test water quality concentrations for DOC were measured in the Granite Canyon reference water, which ranged from <0.055-1.00 mg/L. Harbor samples ranged from 0.654-1.6 mg/L. Dissolved copper concentrations from the Day 2 toxicity test subsamples are included in this table. As expected, the lowest concentrations were found in the Granite Canyon reference water (0.042-0.41 µg/L). The unspiked Harbor samples ranged from 0.749-14.3 µg/L.

Table 9. Day 2 toxicity test water quality data and DOC concentrations used in the Biotic Ligand Model runs.

Measure	Station	Temperature (°C)	pH	Dissolved Cu (µg/L)	DOC (mg/L)	Salinity (ppt)
WER 1 (Summer dry, neap)	MdRH-MC3	17.5	8.02	3.39	0.942	34.0
	MdRH-A	17.6	8.07	7.91	0.914	33.8
	MdRH-B	17.6	8.02	6.95	0.957	33.6
	MdRH-E	17.6	8.01	6.77	1.04	33.8
	MdRH-E Dup	16.9	8.09	7.11	1.04	34.3
	MdRH-F	17.6	8.06	6.35	1.06	34.0
	GC	17.5	8.02	0.132	0.699	33.5
WER 2 (Summer dry, spring)	MdRH-MC3	15.6	7.85	1.78	1.4	33.7
	MdRH-A	15.0	7.84	6.54	1.4	33.4
	MdRH-B	15.2	7.87	5.61	1.4	33.5
	MdRH-E	14.9	7.84	6.09	1.6	33.6
	MdRH-E Dup	15.0	7.93	5.96	1.5	33.4
	MdRH-F	14.8	7.84	5.27	1.5	33.5
	GC	15.9	7.90	0.042	0.94	33.5
WER 3 (Wet)	MdRH-MC3	16.7	7.87	0.749	1.32	34.2
	MdRH-MC3 Dup	17.3	7.86	1.08	1.46	33.3
	MdRH-A	16.2	7.88	11.5	1.58	32.1
	MdRH-B	16.0	7.87	9.17	1.50	31.7
	MdRH-E	16.0	7.87	11.5	1.24	32.1
	MdRH-F	16.1	7.86	9.28	1.27	32.4
	GC	16.0	7.87	0.187	1.00	33.8
WER 5 (Wet)	MdRH-MC3	14.9	7.99	1.94	1.19	32.5
	MdRH-MC3 Dup	14.9	7.96	1.70	1.06	32.2
	MdRH-A	14.9	7.99	7.27	1.06	33.0
	MdRH-B	14.9	8.00	7.99	1.15	31.8
	MdRH-E	14.9	8.00	8.54	1.42	31.9

Measure	Station	Temperature (°C)	pH	Dissolved Cu (µg/L)	DOC (mg/L)	Salinity (ppt)
	MdRH-F	14.9	7.99	7.67	1.32	31.2
	GC	14.9	8.00	0.120	<0.055	34.6
WER 6 (Winter dry, neap)	MdRH-MC3	16.5	7.90	3.36	1.19	34.8
	MdRH-A	16.4	7.85	7.50	1.59	34.9
	MdRH-A Dup	16.1	7.83	7.53	1.39	34.0
	MdRH-B	16.0	7.88	6.88	1.41	34.8
	MdRH-E	16.1	7.82	10.1	1.22	34.9
	MdRH-F	16.2	7.82	6.87	1.16	34.2
	GC	17.0	7.87	0.196	0.966	34.6
WER 7 (Winter dry, spring)	MdRH-MC3	15.5	7.94	2.34	0.839	34.3
	MdRH-A	15.5	7.92	12.7	0.654	34.5
	MdRH-B	15.6	7.92	12.5	0.972	33.5
	MdRH-B Dup	15.6	7.92	14.3	0.976	33.7
	MdRH-E	15.4	7.98	13.1	0.749	32.9
	MdRH-F	15.7	7.92	11.1	0.682	33.7
	GC	15.6	7.93	0.410	0.612	34.2

Note: These are the average values of the individual raw data collected on each sample date. The field duplicates were included in the raw data used for averaging. For raw data, please see sampling summary reports in Appendix C.

6. CHEMISTRY SUMMARY RESULTS

6.1 Dissolved Copper and DOC Summary Results

The measured DOC, copper, and zinc concentrations for composite field samples are summarized in Table 10. Dissolved organic carbon (DOC) concentration is a key factor that can impact copper bioavailability and is one of the input parameters for the biotic ligand model. DOC concentrations in the MdRH WER samples ranged from 0.65-1.6 mg/L for all events, 0.91-1.6 mg/L for summer dry weather, 0.65-1.49 mg/L for winter dry weather, and 1.06-1.58 mg/L for wet weather. The SAC₃₄₀ values provide a qualitative categorization of the possible source of DOC. Using the ranges provided by Al-Reasi et al. (2012), the dry weather samples (WERs 1, 2, 6, and 7) ranged from 1.31-14.1, indicating microbially-derived DOC. This type of DOC is what is typically found in the aquatic environment. Wet weather samples (WERs 3 and 4) ranged from 12.1-23.4. For some of these samples, particularly MdRH-E from WER 3, this value represents a

possible mix of microbially- and terrestrially-derived DOC. The higher SAC₃₄₀ values could be due to some terrestrial DOC input from the wet weather event prior to sampling.

Dissolved copper concentrations ranged from 0.98-17.8 µg/L for all events, 1.78-8.69 µg/L for summer dry weather, 3.45-17.8 µg/L for winter dry weather, and 0.98-12.9 µg/L for wet weather. The highest dissolved copper concentrations (12.5-17.8 µg/L) in the basins were observed in WER 7 (winter dry weather, spring tide), and the lowest dissolved copper concentrations (5.27-6.54 µg/L) in the basins were observed in WER 2 (summer dry weather, spring tide). This trend was also observed for the dissolved zinc concentrations with basin concentrations highest in WER 7 (88.5-118 µg/L) and lowest in WER 2 (34.0-63.3 µg/L).

Table 10. Field chemistry results (DOC concentration, DOC SAC₃₄₀, and dissolved Cu and Zn concentrations) for the composite sample for each station during each sampling event.

Measure	Station	WER 1 (Summer dry, neap)	WER 2 (Summer dry, spring)	WER 3 (Wet)	WER 5 (Wet)	WER 6 (Winter dry, neap)	WER 7 (Winter dry, spring)
DOC (mg/L)	MdRH-MC3	0.94	1.4	1.39*	1.13*	1.19	0.84
	MdRH-A	0.91	1.4	1.58	1.06	1.49*	0.65
	MdRH-B	0.96	1.4	1.50	1.15	1.41	0.98*
	MdRH-E	1.04*	1.6*	1.24	1.42	1.22	0.75
	MdRH-F	1.06	1.5	1.27	1.32	1.16	0.68
DOC SAC ₃₄₀	MdRH-MC3	8.56	7.73	14.1*	13.7*	6.00	9.00
	MdRH-A	7.31	8.39	12.1	15.7	5.94*	13.6
	MdRH-B	9.14	9.87	14.2	13.1	6.60	10.0*
	MdRH-E	6.21*	8.59*	23.4	16.4	8.78	13.3
	MdRH-F	1.31	11.5	15.1	17.9	6.99	14.1
Dissolved Copper (µg/L)	MdRH-MC3	3.64	1.78	0.98*	1.99*	3.45	3.51
	MdRH-A	8.37	6.54	12.7	8.61	8.30*	17.8
	MdRH-B	7.38	5.61	10.2	8.91	7.18	15.2*

Measure	Station	WER 1 (Summer dry, neap)	WER 2 (Summer dry, spring)	WER 3 (Wet)	WER 5 (Wet)	WER 6 (Winter dry, neap)	WER 7 (Winter dry, spring)
	MdRH-E	8.69*	6.03*	12.9	8.97	10.5	14.4
	MdRH-F	7.10	5.27	10.4	8.18	7.63	12.5
Dissolved Zinc (µg/L)	MdRH-MC3	18.4	8.87	7.83*	20.0*	26.5	20.9
	MdRH-A	40.8	35.4	67.2	63.4	50.9*	101
	MdRH-B	39.3	34.0	55.9	64.5	50.0	104*
	MdRH-E	68.8*	63.6*	85.0	83.7	102	118
	MdRH-F	45.8	36.4	58.3	66.0	59.8	88.5

*This is the average value of the sample and field duplicate.

6.2 Comparison to other Copper and DOC Concentrations in MdrH

For this study, dissolved copper was measured during the site characterization sampling (Appendix A) as well as the WER sampling events (Figure 4; Appendix C). Additionally, LACDPW's monthly monitoring program (CIMP) sampled one main channel location monthly and each basin location every other month on a rotating schedule (i.e., Basins A, C, E, and G in January, and Basins B, D, F, and H in February). Dissolved copper concentrations for the site characterization study, which included two summer dry weather events and one wet weather event, ranged from 0.91-8.94 µg/L. The monthly CIMP data collected from March 2018 through December 2020 ranged from 2.48-15.4 µg/L (Mdr CIMP). The California Department of Pesticide Regulation performed a monitoring study in 2006 which sampled 23 marinas statewide, including MdrH (DPR 2009). In this study, MdrH had the highest metals concentrations, with dissolved copper concentrations ranging from 8.1-18.4 µg/L in the back basins (BB) and 8.9-16.2 µg/L in the front basins (FB).

The range of copper concentrations measured in the CIMP samples from 2018-2020 is reflective of the range of concentrations observed in the site characterization and WER samples (0.91-17.8 µg/L). The basin samples from the DPR study (8.1-18.4 µg/L) had a similar but slightly higher concentration range compared to the WER basin samples (5.27-17.8 µg/L).

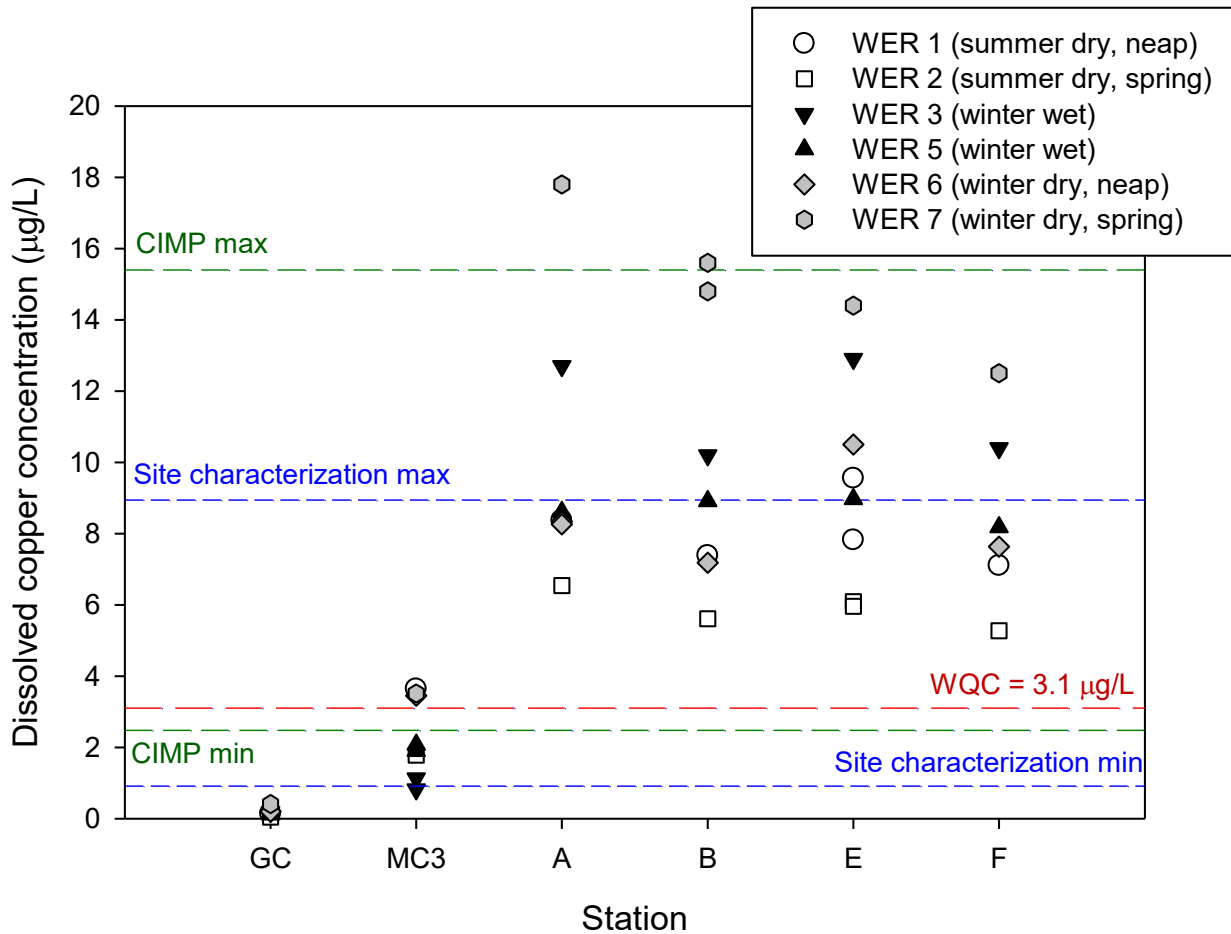


Figure 4. Dissolved copper concentrations in Granite Canyon (GC) reference water and MdrH composite field samples by station (x-axis) and by sampling event (symbol). The blue dashed lines represent the minimum and maximum concentrations observed in the site characterization study. The green dashed lines represent the minimum and maximum concentrations observed in the CIMP from March 2018 through December 2020. The red dashed line represents the current water quality criterion (3.1 µg/L).

Dissolved organic carbon was not previously sampled monthly during the CIMP sample collections. Based on the recommendation from the TAC, DOC sample collection was added to the program from April 2019 through February 2020. These samples were collected on the same schedule as the dissolved copper samples detailed above. The CIMP DOC data ranged from 0.44-1.4 mg/L (Appendix E). The 2006 DPR study reported DOC concentrations in MdrH

ranging from 0.69-1.90 mg/L (DPR 2009). Overall, both of these supplemental data sets reflect a similar range of DOC concentrations as observed in the WER samples (0.65-1.6 mg/L; Figure 5).

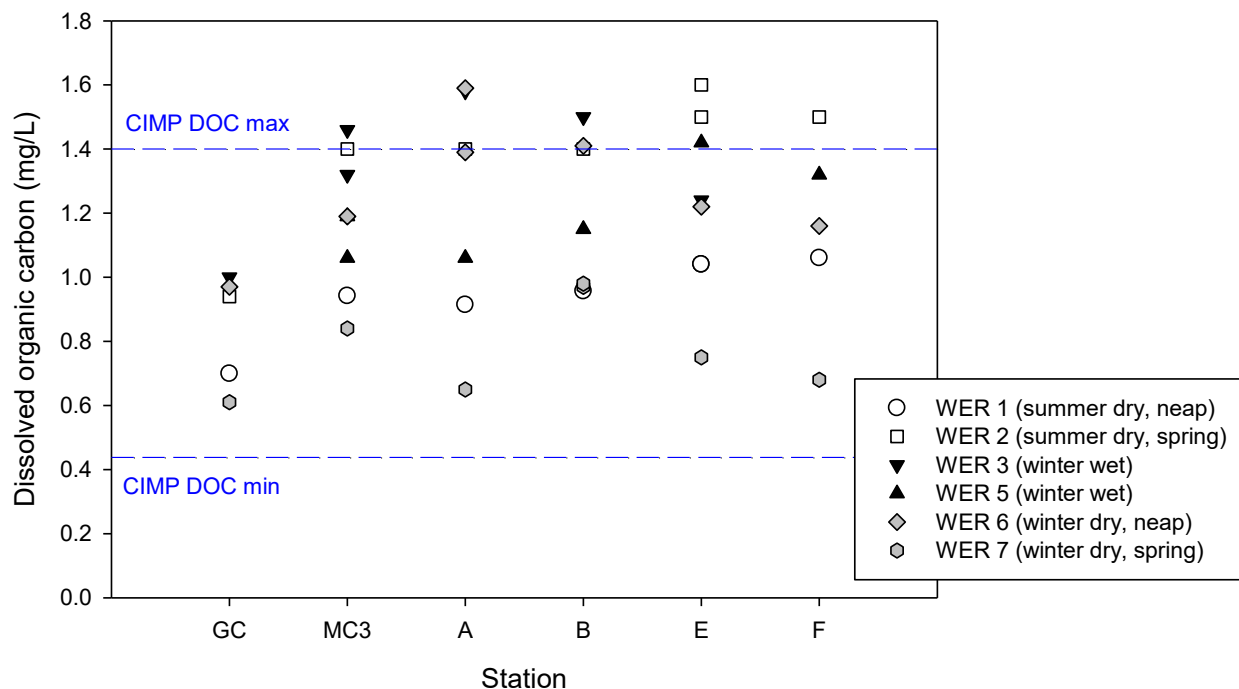


Figure 5. DOC concentrations in Granite Canyon (GC) reference water and MdrRH composite field samples by station (x-axis) and by sampling event (symbol). The blue dashed lines represent the minimum and maximum concentrations observed in the monthly CIMP DOC monitoring.

7. WER RESULTS

7.1 Toxicity-based WERs

Table 11 summarizes the sample WERs calculated for each station during each sampling event. These values were calculated as the ratio of the toxicity test EC50 value for each sample divided by the EC50 value of the Granite Canyon reference water (Equation 1, Section 3.3). The toxicity test results and EC50 values are further detailed in the event summary reports (Appendix C). A mean was calculated for the station with the field duplicate as indicated by the asterisk.

Of the 30 samples collected over all sampling events, 24 sample WERs could be calculated and six sample WERs could not be calculated. In events 1, 2, and 5, WERs were calculated for all the samples collected. In WER 3, the MdrRH-MC3 sample dose-response did not provide enough toxicity to calculate an EC50 value. As such, the dose-response range was modified for future tests to ensure an appropriate range of toxicity response. In WER 6, the MdrRH-E sample exhibited ambient toxicity which exceeded 50% abnormal development, resulting in the inability to calculate an EC50 value for that sample. In WER 7, all four of the basin samples exhibited ambient toxicity which exceeded 50% abnormal development, resulting in the inability to calculate an EC50 value for those samples.

Overall, the WERs ranged from 0.925 (WER 6, MdRH-A) to 2.04 (WER 5, MdRH-F). WERs were lowest in winter dry weather (0.925-1.27), followed by summer dry weather (1.27-1.44). The highest WERs were observed in wet weather (1.54-2.04). The geometric mean of all samples (n = 24) was 1.40.

Table 11. Toxicity-based sample WER (sWER) values calculated for each of the sampling events.

Station	WER 1 (summer dry, neap)	WER 2 (summer dry, spring)	WER 3 (wet)	WER 5 (wet)	WER 6 (winter dry, neap)	WER 7 (winter dry, Spring)	Unweighted	Weather- weighted
MdRH-MC3	1.28	1.33	--*	1.62 (mean)*	1.00	1.27		
MdRH-A	1.30	1.35	1.54	1.72	0.925 (mean)*	--		
MdRH-B	1.34	1.35	1.59	1.76	1.01	--*		
MdRH-E	1.28 (mean)*	1.44 (mean)*	1.59	1.94	--	--		
MdRH-F	1.36	1.44	1.57	2.04	1.09	--		
Geometric Mean	1.31	1.38	1.57	1.81	1.00	--	1.40	1.32

*The mean sWER is reported for the station with the field duplicate.
Note: Missing values indicate a WER could not be calculated.

7.2 BLM-based WERs

Table 12 summarizes the sample WERs calculated for each station based on the predicted EC50 value generated by the biotic ligand model. These values were calculated as the ratio of the BLM-predicted EC50 value for each sample divided by the BLM-predicted EC50 value of the Granite Canyon reference water (Equation 6, Section 3.4). The model input data was based on the measured DOC concentration from the field and Granite Canyon samples, as well as the pH, temperature, and salinity measured in the toxicity test vials on Day 2. A mean was calculated for the station with the field duplicate as indicated by the asterisk. These results are further detailed in the event summary reports (Appendix C).

The high results in WER 5 were driven by the low DOC concentration observed in the Granite Canyon reference water (below detection limit, < 0.055 mg/L). No significant changes in other water quality parameters (i.e., pH and salinity) were observed, and no other issues were observed with the DOC quality control samples. As such, the detection limit concentration (0.055 mg/L) was used as the input value for the reference water EC50 model simulation. After discussion, the TAC determined the WER 5 sWERs were outliers. These values were reported as the outcome for that event, but the sWERs were excluded from the recommended final WER analysis and comparison with the toxicity-based WERs.

Overall, the BLM-based WERs ranged from 1.07 (WER 7, MdRH-A) to 1.65 (WER 2, MdRH-E). WERs were lowest in winter dry weather (1.07-1.59), followed by the WER 3 wet weather event (1.23-1.56), and then the summer dry weather (1.30-1.65). The geometric mean of all samples, excluding WER 5 (n = 24) was 1.38.

Table 12. BLM-based predicted sample WER values calculated for each of the sampling events.

Station	WER 1 (summer dry, neap)	WER 2 (summer dry, spring)	WER 3 (wet)	WER 5 [†] (wet)	WER 6 (winter dry, neap)	WER 7 (winter dry, Spring)	Unweighted	Weather- weighted
MdRH-MC3	1.35	1.49	1.39 (mean)*	[19.0] (mean)*	1.24	1.37		
MdRH-A	1.30	1.48	1.56	[17.9]	1.54 (mean)*	1.07		
MdRH-B	1.37	1.49	1.48	[19.9]	1.46	1.59 (mean)*		
MdRH-E	1.49 (mean)*	1.65 (mean)*	1.23	[23.9]	1.26	1.21		
MdRH-F	1.51	1.59	1.26	[22.1]	1.19	1.11		
Geometric Mean	1.40	1.54	1.38	[20.5]	1.33	1.26	1.38 [2.16]	1.38 [1.77]

*The mean sWER is reported for the station with the field duplicate.

†The WER 5 results were reported in the table in brackets. A geometric mean was calculated excluding those values (not bracketed) and including those values (bracketed).

The dry weather BLM-based WERs were higher but in the same range as the toxicity-based WERs (Figure 6). The geometric means for the toxicity-based and BLM-based WERs for the four dry events (WERs 1, 2, 6, 7) ranged from 1.00-1.38 and 1.26-1.54, respectively. The wet weather WERs did not exhibit a consistent trend. For WER 3, the geometric means for the toxicity-based and BLM-based WERs were 1.57 and 1.38, respectively.

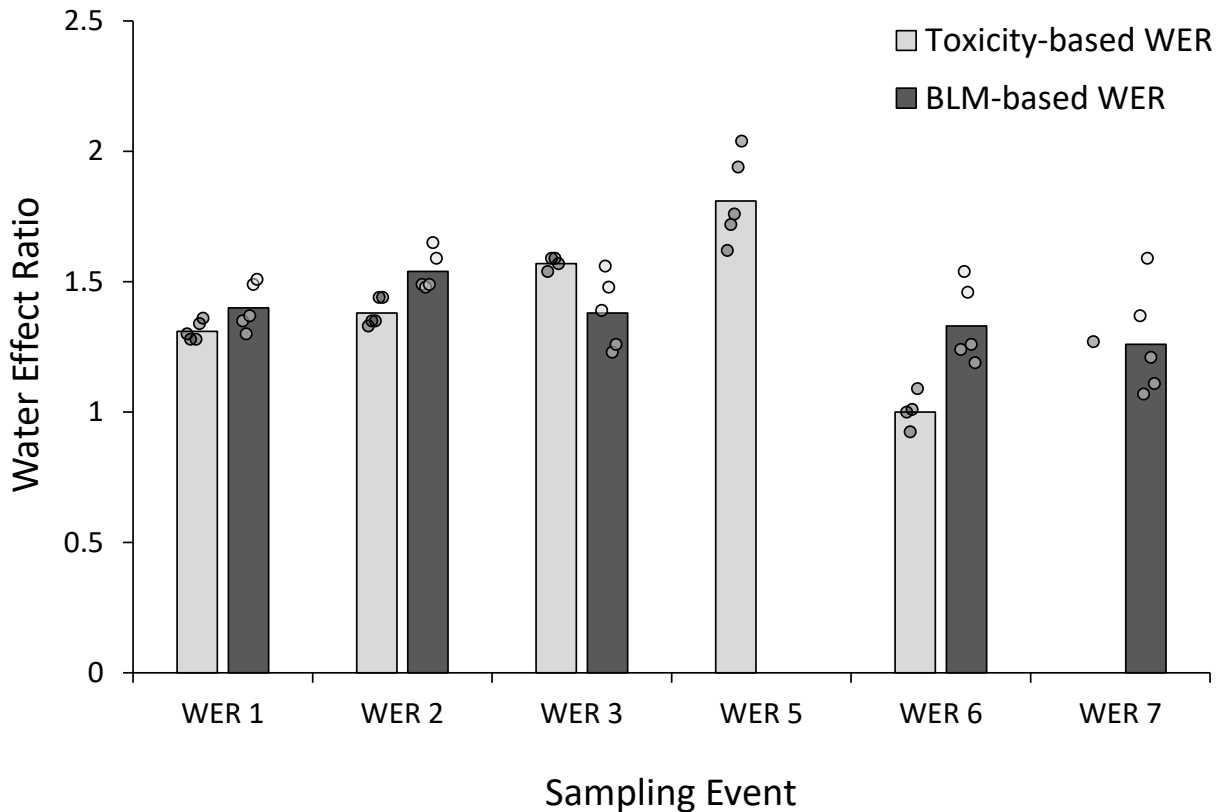


Figure 6. Comparison of the geometric means of the toxicity-based (light gray bars) and BLM-based (dark gray bars) WERs for each sampling event. The individual WER values are represented in the scatterplot overlay. The WER 5 BLM results were excluded as outliers.

8. FINAL WER CALCULATIONS AND ANALYSIS

8.1 fWER calculation

The final WER was calculated using two methods: unweighted and weather-weighted (See section 3.3 for calculations). Both the unweighted and weather-weighted fWERs were reported for the toxicity-based and BLM-based WERs (Tables 11 and 12). The unweighted geometric mean using all sWERS was 1.40. The weather-weighted geometric mean was 1.32. Since the lowest sWERS occurred during dry weather, and dry weather comprises over 90% of the year in Los Angeles, the weather-weighted geometric mean is lower than the unweighted geometric mean.

The primary advantage of using the unweighted fWER is that this calculation method is consistent with EPA guidance (USEPA 2001). This is also the same calculation method used for the fWERs in San Francisco Bay and San Diego Bay. Another advantage is that the unweighted geometric mean approach for calculating the fWER is sample size. A total of 24 sWERS are used for calculating the unweighted fWER (values from Table 11, Section 6.1) over six sampling events, which exceeds the minimum fWER guidance from the USEPA requiring a minimum of

three sampling events, with at least three of four WER measurements considered for the fWER calculation.

The primary advantage of using the weather-weighted fWER is representativeness. The distribution of samples across dry and wet weather was not proportional to the amount of time during the year when it is raining (or not raining) in MdR. The sampling design in this study targeted 33% of samples in wet weather and 66% of samples in dry weather. This compares to the 10% wet weather days and 90% dry weather days in an average year in MdR. To account for this discrepancy in representativeness, mathematical weighting is a widely accepted statistical approach (Sokal and Rohlf 1994). The TAC noted during their deliberations that the study was not designed with wet versus dry weather proportional representativeness. Instead, the recommended study design was balancing sufficient sample size to estimate wet weather sWER with confidence.

The TAC achieved consensus that a single fWER should be used year-round. This consensus recommendation assumed implementation activities will be consistent year-round (i.e., replacing copper-containing vessel bottom paints) and not intermittent or seasonal implementation activities. However, the TAC members did not reach consensus on which calculation method was most appropriate. The majority opinion favored the weather-weighted fWER and the minority opinion favored the unweighted fWER. The TAC did agree that both the unweighted and weather-weighted fWERs should be presented in this report and, ultimately, the regulated and regulatory stakeholders should pick which fWER is appropriate as part of the implementation plan.

8.2 Protectiveness calculation

The current water quality criterion for dissolved copper is 3.1 µg/L and is based on being protective of the most sensitive species, *Mytilus sp.* (EC50 value of 6.19 µg/L; USEPA 2003 and 2016b). This EC50 value was used as the lowered final acute value (FAV) to protect *Mytilus sp.* and was divided by 2 to develop the copper criterion of 3.1 µg/L.

This protectiveness calculation approach was used in the Copper WER study in the Los Angeles River (Steering Committee 2014) and was applied here. To evaluate the protectiveness of the fWER generated from this study, the calculation used by the USEPA to develop the criterion from the FAV can be reversed such that the measured EC50 values for a sample can be divided by the proposed revised criterion (current criterion * fWER; Equation 7). If the result is 2 or greater, the fWER can be considered protective for the waterbody as it reflects a condition which is similar to the EC50 values used in the development of the criterion.

$$\text{Ratio} = \frac{\text{EC50 Site water}}{\text{Criterion} * \text{fWER}} \quad (7)$$

The average EC50 value for each WER event was used in the calculation. The criterion (3.1 µg/L) multiplied by the unweighted fWER (1.40) results in a denominator of 4.34 µg/L. The ratios ranged from 2.18 (WER 7) to 3.60 (WER 3), which are greater than 2.0, and therefore indicates the fWER should result in a new criterion that remains protective. The weather-

weighted fWER resulted in ratios that ranged from 2.31 (WER 7) to 3.81 (WER 3), indicating a new criterion using that value also remains protective.

8.3 Comparison to Previous WERs in California

WER studies have frequently been performed in freshwater environments; however, only a few WER studies have been conducted in California marine or estuarine waters (Table 13). To this date, only two have resulted in SSOs that were adopted by a RWQCB and approved by the SWRCB. For the studies which have not/not yet been adopted by the relevant RWQCB, the results still provide an important point of comparison for the WER results (LWA 2006, 1995; Bosse 2014).

Lower South San Francisco Bay (South of Dumbarton Bridge)

An impairment assessment study for copper (and nickel) was conducted for Lower South San Francisco Bay (Tetra Tech et al. 2000). WER testing was a key part of this study and was used to understand how site-specific water quality parameters affect the bioavailability and toxicity of dissolved copper within the Lower South San Francisco Bay. The blue mussel *Mytilus edulis* and the purple sea urchin *Strongylocentrotus purpuratus* were used in this testing as primary and secondary species, respectively. Samples were collected from three sites in South San Francisco Bay, and tests were conducted from January 1996 to March 1997 to understand the temporal variability in copper bioavailability in Lower South San Francisco Bay waters. Results of this study demonstrated WER values ranging from 2.7 to 3.5 for dissolved copper. SSOs ranging from 6.7 to 8.8 µg/L for dissolved copper were then calculated using a modified CCC of 2.5 µg/L, based on toxicity test data collected as part of the study. A proposed SSO of 6.9 µg/L was recommended by the City of San Jose, based on pooled WER results from two stations and was suggested to be protective of the most sensitive species, *M. edulis*. An SSO of 6.9 µg/L was adopted by the San Francisco Bay RWQCB in 2002 (San Francisco Bay RWQCB 2002).

San Francisco Bay (North of Dumbarton Bridge)

A WER study was conducted in San Francisco Bay in 2000/2001 for purposes of developing copper SSOs for San Francisco Bay regions north of the Dumbarton Bridge (Clean Estuary Partnership 2005; San Francisco Bay RWQCB 2007a). Sampling was conducted at 13 stations that were selected based on stations previously sampled by the Regional Monitoring Program. The study involved sampling and WER testing during two dry seasons (September 2000 and June 2001) and two wet season (January and March 2001) events. Copper toxicity tests were performed using the bivalve *M. edulis* mussel development test. Results did not demonstrate a seasonal pattern in WERs; however, differences in WERs across San Francisco Bay regions were measured and were likely due to differences in the physicochemical characteristics of water from different regions of San Francisco Bay. The geometric mean WERs for the San Francisco Bay regions north of San Bruno Shoal (i.e., north of Oakland airport on the eastern side and north of Little Coyote Point on the western side) ranged from 2.40 to 2.49 and the geometric mean WER for the region south of San Bruno Shoal was 2.90. Based on these findings, the Basin Plan Amendment proposed chronic and acute copper SSOs of 6.0 and 9.4 µg/L, respectively, for the area north of San Bruno Shoal and chronic and acute copper SSOs of 6.9 and 10.8 µg/L,

respectively, for the region south of San Bruno Shoal. These SSOs were adopted by the San Francisco Bay RWQCB in 2007 (San Francisco Bay RWQCB 2007b).

San Diego Bay Studies

Rosen et al. (2005) evaluated the bioavailability of copper to organisms in the San Diego Bay. Water samples included composite and grab samples that were collected from various locations inside the bay from 2000 to 2002. Bivalve *Mytilus galloprovincialis* and echinoderm *S. purpuratus* or *Dendraster excentricus* embryos were used in WER toxicity tests. For WER calculations, EC50s from the copper-spiked San Diego Bay water samples (from various areas of the Bay) were compared to those from toxicity tests of copper-spiked reference seawater, which was filtered (0.45 micron) coastal seawater collected from the research pier at Scripps Institute of Oceanography. Bay-wide estimates of the dissolved copper WER based on the *M. galloprovincialis* EC50 values ranged from 1.62 to 1.72, with a geometric mean of 1.67. These findings of WERs greater than 1 in San Diego Bay suggest that an SSO of 5.2 µg/L (based on the WER range above) would be protective of the organisms throughout San Diego Bay.

More recently, a study of the bioavailability and toxicity of copper was conducted in Shelter Island Yacht Basin, a marina in North San Diego Bay (Bosse et al. 2014). As part of this study, WER sampling and testing was conducted in conjunction with copper complexation capacity measurements and modeling using the marine BLM. Samples were collected at two depths (near surface and near bottom) during two sampling events, representing the wet season and the dry season. Sampling for ambient toxicity occurred at 15 to 16 stations during each event, and samples from four of these stations were spiked with copper for use in WER testing. *M. galloprovincialis* embryos were used as the test species as part of the standard mussel development test (USEPA 1995). Results of this study demonstrated slightly lower WERs in the wet season (geometric mean of 1.2 ± 0.1) than in the dry season (geometric mean of 1.5 ± 0.2) with a final dissolved copper WER for all events of 1.33. These findings suggest that an SSO of 4.11 µg/L would be protective of marine organisms in the Shelter Island Yacht Basin.

Mugu Lagoon and Lower Calleguas Creek, Ventura County

A WER study for copper was conducted for Mugu Lagoon and Lower Calleguas Creek (LWA 2006) in accordance with the USEPA (1994) Interim Guidance. However, only the results for Mugu Lagoon, which is a marine environment, are relevant to the current study and are summarized here. Samples were collected during dry weather conditions in August 2003 and January 2004 and wet weather conditions in March 2004 and April 2006. *M. edulis* were the primary test species, and the larval bivalve development test was used to evaluate copper toxicity. The recommended WER for dissolved copper in Mugu Lagoon was determined to be 1.51, resulting in a chronic SSO established as 4.68 µg/L (LWA 2006).

Summary of Previous Water-Effect Ratio Studies

All studies summarized above have demonstrated that WER results were greater than 1. Final WER findings from these studies ranged from 1.33 in Shelter Island Yacht Basin to 2.77 in Lower South San Francisco Bay. These findings suggest that at each of these sites, a higher

copper concentration than the current CTR CCC criterion of 3.1 µg/L would be protective of marine aquatic life and beneficial uses of those sites.

Table 13. Summary of WER results from this study and other copper WER studies in California bays and estuaries.

Study	fWER	Minimum sWER	Maximum sWER
MdRH SSO	1.40 (1.32)	0.92	2.04
Shelter Island Yacht Basin (San Diego Bay)	1.33	1.07	1.65
San Diego Bay	1.67	1.62	1.72
Mugu Lagoon	1.51	1.26	4.03
Lower South San Francisco Bay-South of Dumbarton Bridge	2.77*	2.77	3.00
San Francisco Bay-North of Dumbarton Bridge (North of San Bruno Shoal)	2.40*	1.50	5.30
San Francisco Bay-North of Dumbarton Bridge (South of San Bruno Shoal)	2.77*	2.20	5.20

*New SSOs adopted by the San Francisco Bay RWQCB based on these fWERs.
 Note: The MdRH SSO fWER values are presented as unweighted (weather-weighted).

8.4 TAC Recommendation

The Technical Advisory Committee (TAC) members reviewed the results and summary reports for all WER sampling events throughout the project timeline. After all WER events were summarized, the TAC discussed the SSO implementation process with LACPW and LARWQCB, and provided three recommendations for calculating the final WER:

1. The TAC recommended using a single fWER for year-round application in Marina del Rey since implementation activities will likely be consistent year-round;
2. The TAC recommended a single fWER for the entire Harbor since there were no spatial differences deemed significant enough to warrant multiple values based on different locations within the Harbor, and;
3. The TAC recommended either the unweighted or weather-weighted geometric mean for the fWER. The unweighted fWER is 1.40 and the weather-weighted fWER is 1.32. The decision on whether to use the unweighted or weather-weighted geometric mean for developing site-specific objectives for copper should be made by the regulated and regulatory stakeholders during implementation planning.

9. REFERENCES

- Al-Reasi, H.A. and D.S. Smith. 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.
- Arnold, W.R., R.C. Santore, and J.S. Cotsifas. 2005. Predicting copper toxicity in estuarine and marine waters using the biotic ligand model. *Marine pollution bulletin*, 50: 1634-1640.
- Bosse, C., G. Rosen, M. Colvin, P. Earley, R. Santore, and I. Rivera-Duarte. 2014. Copper bioavailability and toxicity to *Mytilus galloprovincialis* in Shelter Island Yacht Basin, San Diego, California. *Marine Pollution Bulletin*, 85:1634-1640.
- Chadwick, D.B., I. Rivera-Duarte, G. Rosen, P.F. Wang, R.C. Santore, A.C. Ryan, P.R. Paquin, S.D. Hafner, and W. Choi. 2008. Demonstration of an Integrated Compliance Model for Predicting Copper Fate and Effects in DoD Harbors. Environmental Security Technology Certification Program (ESTCP). Project ER-0523. Technical Report 1973. December 2008.
- Clean Estuary Partnership. 2005. North of Dumbarton Bridge Copper and Nickel Site-Specific Objective (SSO) Derivation. Prepared by EOA, Inc., and Larry Walker Associates. March 2005.
- Di Toro, D.M., H.E. Allen, H.L. Bergman, J.S. Meyer, P.R. Paquin, and R.C. Santore. 2001. Biotic ligand model of the acute toxicity of metals. Technical basis. *Environmental Toxicology and Chemistry*, 20: 2383-2396.
- DPR. 2009. Monitoring for Indicators of Antifouling Paint Pollution in California Marinas. EH08-05. Environmental Monitoring Branch. California Department of Pesticide Regulation. Sacramento, CA.
- LWA (Larry Walker Associates). 2006. Calleguas Creek Watershed Copper Water-Effects Ratio (WER) Study. June 8, 2006.
- Los Angeles RWQCB. 2014. State of California Regional Water Quality Control Board, Los Angeles Region. Resolution No. R14-004. Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise the Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor. February 6, 2014.
- Los Angeles RWQCB/USEPA (Los Angeles Regional Water Quality Control Board and U.S. Environmental Protection Agency). 2005. Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor. October 6, 2005.
- Rosen, G., I. Rivera Duarte, L. Kear Padilla, and D.B. Chadwick. 2005. Use of laboratory toxicity tests with bivalve and echinoderm embryos to evaluate the bioavailability of copper in San Diego Bay, California, USA. *Environmental Toxicology and Chemistry*, 24: 415-422.
- San Francisco Bay RWQCB (San Francisco Bay Regional Water Quality Control Board). 2002. Resolution R-2002-0061. Amending Water Quality Control Plan for the San Francisco Bay Region to Adopt Site-Specific Objectives for Copper and Nickel in the Lower South San Francisco Bay and an Implementation Plan. May 22, 2002.

- San Francisco Bay RWQCB. 2007a. Copper Site-Specific Objectives in San Francisco Bay. Proposed Basin Plan Amendment and Draft Staff Report. June 6, 2007.
- San Francisco Bay RWQCB. 2007b. Resolution R2-2007-0042. To amend the Water Quality Control Plan for the San Francisco Bay Region to Adopt Site-Specific Objectives for Copper for San Francisco Bay and an Implementation Plan. June 13, 2007.
- Santore, R.C., D.M. Di Toro, P.R. Paquin, H.E. Allen, and J.S. Meyer. 2001. Biotic ligand model of the acute toxicity of metals. 2. Application to acute copper toxicity in freshwater fish and *Daphnia*. *Environmental Toxicology and Chemistry*, 20:2397-2402.
- Sokal, R.R. and F.J. Rohlf. 1994. *Biometry: The Principles and Practices of Statistics in Biological Research*, 3rd Edition. Freeman Publishers. New York, NY. 880 pp.
- Steering Committee (Los Angeles River Metals Total Maximum Daily Load Special Studies Steering Committee). 2014. Final Report, Copper Water-Effect Ratio Study to Support Implementation of the Los Angeles River and Tributaries Metals TMDL. Prepared by Larry Walker Associates on behalf of the Los Angeles River Metals Total Maximum Daily Load Special Studies Steering Committee.
- SWRCB (State Water Resources Control Board). 2014. Resolution No. 2014-0049. Approving an Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise a Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor. September 9, 2014. Available from: http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/tmdl/tmdl_list.shtml.
- Tait, T.N., C.A. Cooper, J.C. McGeer, C.M. Wood, and D.S. Smith. 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.
- Tetra Tech, Inc.; Ross & Associates, Ltd.; and EOA, Inc., 2000. Task 2 Impairment Assessment Report for Copper and Nickel in Lower South San Francisco Bay. Sponsored by the City of San Jose. Final Report. June 2000.
- USEPA (U.S. Environmental Protection Agency). 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. USEPA-823-B-94-001. Office of Water and Office of Science and Technology, Washington, D.C. February 1994.
- USEPA. 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.
- USEPA. 2001. Streamlined Water-Effect Ratio Procedure for Discharges of Copper. USEPA/822/R-01/005. Office of Water. Washington, DC.
- USEPA. 2003. 2003 Draft update of ambient water quality criteria for copper. USEPA-822-R-03-026. Office of Water and Office of Science and Technology, Washington, D.C. November 2003. Available at: <https://archive.epa.gov/epa/sites/production/files/2019-02/documents/2003-draft-update-awqc-copper.pdf>.

USEPA. 2016a. Draft Estuarine/Marine Biotic Ligand Model, EPA Estuarine/Marine Copper Water Quality Criteria Version 0.6.2.39: User's Guide and Reference Manual. Office of Water. Washington, DC.

USEPA. 2016b. Draft Aquatic Life Ambient Estuarine/Marine Water Quality Criteria For Copper – 2016. EPA-822-P-16-001. Office of Water. Washington, DC.

SCCWRP and Latitude Environmental. 2019. Final Work Plan: Marina del Rey Harbor Site-specific Objective study. Prepared by Southern California Coastal Water Research Project (SCCWRP) and Latitude Environmental, Inc on behalf of Los Angeles County Public Works and Department of Beaches and Harbors. July 2019.

APPENDIX A: SITE CHARACTERIZATION SUMMARY REPORT

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February 26, 2019

Introduction

The USEPA interim guidance for water effect ratio (WER) determination emphasizes the importance of using a sampling design that considers variations in water quality likely to affect the WER (USEPA 1994). EPA has not developed a generalized specific study design for WER studies at large sites such as MdrRH. Rather, conceptual guidance for design development is provided:

“Each design has to be formulated individually to fit the specific site. The design should try to take into account the times, locations, and depths at which the extremes of the physical, chemical, and biological conditions occur within the site, which will require detailed information concerning the site.”

Potential sources of variability include seasonality (e.g., summer vs. winter), presence of stormwater discharge, hydrology (tides or depth), and episodic events (e.g., plankton blooms, harbor activities). The relative importance of these factors on WERs in Marina del Rey Harbor (MdrRH) is not known.

Included within the combination of various site characteristics is the “critical condition” defined by EPA as: “...*the critical condition, that condition where the copper concentration can be expected to be highest relative to the WER...*” (USEPA 2001). A common goal of all WER studies to identify site-specific objectives that will protect water quality under the critical condition.

Prior monitoring of MdrRH for metals shows that elevated copper concentrations occur throughout the harbor. Consistent spatial patterns in MdrRH copper are weak, due to the diffuse nature of the primary source (i.e., leaching from thousands of boat hulls distributed among multiple locations). Thus, the critical condition for MdrRH can also be defined as that combination of factors resulting in the lowest WER, with the assumption that the location of areas with the highest copper concentration is variable.

This report summarizes the results of field studies to characterize the magnitude and variability in water quality characteristics likely to influence the WER in MdrRH. Three site characterization sampling events were conducted in 2018 and included measurements of water quality characteristics known to influence copper bioavailability (e.g., pH, dissolved organic carbon, salinity), as well as copper concentration and toxicity. The results are interpreted with the objective of identifying spatial or temporal patterns that are likely to represent the critical condition for a copper WER in MdrRH.

Study Design

The site characterization studies were designed to evaluate the spatial and temporal variability in water quality factors considered to be important to determining copper bioavailability in MdrRH. Spatial variability was assessed by analyzing water samples from 11 stations located throughout the harbor (Figure 1). These stations represented three different hydrologic regions of the harbor (main channel, front basins, back basins), as well as potential discharges from point (shipyard) and nonpoint sources (Ballona Creek, Oxford Basin, storm drains). Sample depth was also considered, by collecting samples from both near surface and near bottom. Temporal variability was investigated by conducting sampling on three events, with each representing different seasonal conditions: winter-wet weather, spring-dry weather, summer-dry weather. Short-term variability in water characteristics, potentially related to tidal exchange, was investigated during the summer sampling event by collecting multiple samples from the same location at different times of the day. A summary of the sampling events is shown in Table 1.

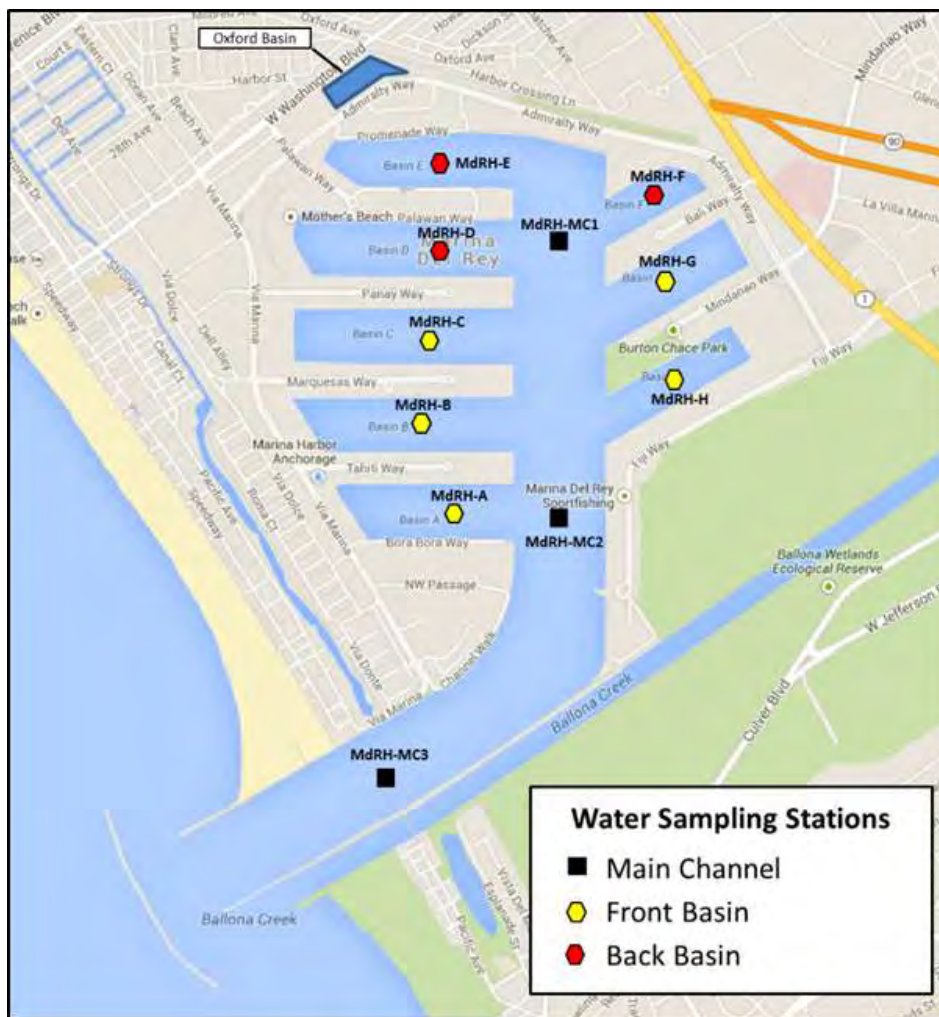


Figure 1. Station locations in Marina del Rey Harbor.

Table 1. Site characterization study design parameters.

Event	Date	Weather	Precipitation (inches)	Sampling depths	Tide Stage		Tide height range relative to MLLW (ft)	Duplicate samples	Stations with repetitive sampling
					Flood	Ebb			
1	3/23/2018	Wet	1.1	B, S	X		0.61 to 2.95	1	0
2	5/21/2018	Dry	0	B, S	X		-0.22 to 3.14	1	0
3	9/10/2018	Dry	0	S	X	X	3.0 to 5.7	2	2

B=bottom depth

S=surface depth

MLLW=mean lower low water

Methods

Water samples were collected from each of the stations using a peristaltic pump and Teflon-lined tubing (Table 2). Samples from two-depths (1 m above the sediment and 1 m below the water surface) were collected in the first two events. Event 3 samples were collected from the surface only. The specific coordinates listed (Table 2) are from the third sampling event. The timing of each collection event was planned to collect samples from at least two different tide profiles to evaluate potential effects from tide on the critical condition. For all events, sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day. The tidal ranges for each sampling period are presented as a function of time (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>).

Subsamples were immediately filtered through a 0.45 µm polyethersulfone syringe filter for analysis of dissolved metals and dissolved organic carbon (DOC). Additional subsamples were taken for analysis of total metals, toxicity, and chlorophyll. Field measurements of sample pH, dissolved oxygen (DO), temperature, and salinity were made using electrodes.

Dissolved and total concentrations of copper and zinc were measured. Metal analysis was conducted according to USEPA Method 1640 for trace elements in water, using inductively coupled plasma mass spectrometry. In this procedure, trace elements are pre-concentrated based on their reductive precipitation by sodium tetrahydroborate; iron and palladium are added to samples to aid co-precipitation of metal borides and to enhance the precipitation of metals coming out in the elemental form.

Dissolved organic carbon analyses were conducted using USEPA Method 9060a for the analysis of organic carbon by combustion or oxidation.

Toxicity of the water samples was measured with the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The test was conducted under standard conditions specified by USEPA guidance. Toxicity tests were initiated within 48 hours of sample collection. Embryos were preserved for examination at the end of the exposure period. The preserved samples were examined using a microscope to determine the numbers of normal and abnormal surviving embryos. The percent of normal embryos was calculated from the count.

To better evaluate differences in the water quality data collected over time and depth several statistical analyses were applied. One-way analysis of variance (ANOVA) was used to determine if there were significant differences in DOC, chlorophyll, or dissolved copper concentration by time for all three events. If significant, the Tukey HSD post-hoc test was used to determine the differences. A t-test was also used to determine if there were significant differences by depth for events 1 and 2. Additionally, it was used to determine if the duplicate DOC and chlorophyll data were significantly different from the repeated visit data. Spearman's correlation analysis was also used. Significance was determined if the p value was less than an alpha level of 0.05.

The marine Biotic Ligand Model (BLM) was used to predict the potential for copper toxicity using site water quality data (Arnold et al. 2005). This BLM is currently under review by the USEPA but has not yet been approved for use in water quality criteria development. Water quality data (pH, temperature, DOC, and salinity) from all three sampling events were used in the BLM to calculate a site-specific predicted copper EC50 value for each sample. This value is comparable to an EC50 value for the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). This embryo development test was used to evaluate the toxicity of samples collected from each of the three site characterization events.

Table 2. Station location coordinates within Marina del Rey Harbor.

Station ID	Description	Latitude	Longitude
MdRH-MC1	Main Channel, end	N 33° 58.814'	W 118° 26.886'
MdRH-MC2	Main Channel, middle	N 33° 58.330'	W 118° 26.892'
MdRH-MC3	Main Channel, entrance	N 33° 58.880'	W 118° 27.316'
MdRH-A	Front Basin A, middle	N 33° 58.348'	W 118° 27.194'
MdRH-B	Front Basin B, middle	N 33° 58.504'	W 118° 27.189'
MdRH-C	Front Basin C, middle	N 33° 58.665'	W 118° 27.253'
MdRH-D	Back Basin D, middle	N 33° 58.827'	W 118° 27.243'
MdRH-E	Back Basin E, middle	N 33° 58.977'	W 118° 27.191'
MdRH-F	Back Basin F, middle	N 33° 58.919'	W 118° 26.697'
MdRH-G	Front Basin G, middle	N 33° 58.776'	W 118° 26.626'
MdRH-H	Front Basin H, middle	N 33° 58.584'	W 118° 26.676'

Results

Sampling

Winter-wet weather event

During the winter-wet weather event, the previous 48 hours produced 1.1 inches of rainfall at the Ballona Creek rain gauge, which was above the minimum required rainfall of 0.2 inches specified in the draft work plan. Surrounding areas had rainfall values of 1.41 inches (Santa Monica, north of MdrRH), and 0.75 inches (83rd Street Yard, south of MdrRH). Sampling started at 8:20 a.m. and ended at 5:15 p.m.. The first sample (MdrRH-H surface) was taken just before the low tide at 0.7 ft, and the final sample (MdrRH-MC1 bottom) was taken around the high tide of +2.9 ft. The overall tide change for the day was +2.3 ft (Figure 2).

Spring-dry weather event

Sampling started at 8:40 a.m. and ended at 2:37 p.m. The tidal regime for this event was similar to that for the winter sampling. The first sample (MdrRH-MC3 surface) was taken just before the low tide at +0.16 ft, and the final sample (MdrRH-H bottom) was taken around the high tide of +3.14 ft. The overall tide change for the day was +3.36 ft.

Summer-dry weather event

Sampling started at 7:44 a.m. and ended at 12:25 p.m. The first sample (MdrRH-H-1 surface) was taken approximately 3.5 hours after the low tide (-0.35 ft) at +3.0 ft, and the final sample (MdrRH-H-3 surface) was taken approximately two hours after the high tide (+5.75 ft) at +4.63 ft. The overall tide change for the sampling window was +2.75 ft.

Water Quality

All results for water quality, metals concentrations, toxicity, and BLM-based predicted EC50 values for each event are reported in the Appendix. Harbor-wide averages for each sampling event are shown in Table 3.

Salinity measurements showed little change over time and depth. However, there was higher variability in the salinity data during the wet weather event (higher coefficient of variation), which could be due to the freshwater input from rainfall and runoff. Temperature did not vary much by depth but showed a steady increase over time moving from winter through summer. The average pH values were within 0.1 pH units, with similar pH values measured in March and September (7.95) and a slightly reduced pH value (7.84) in May.

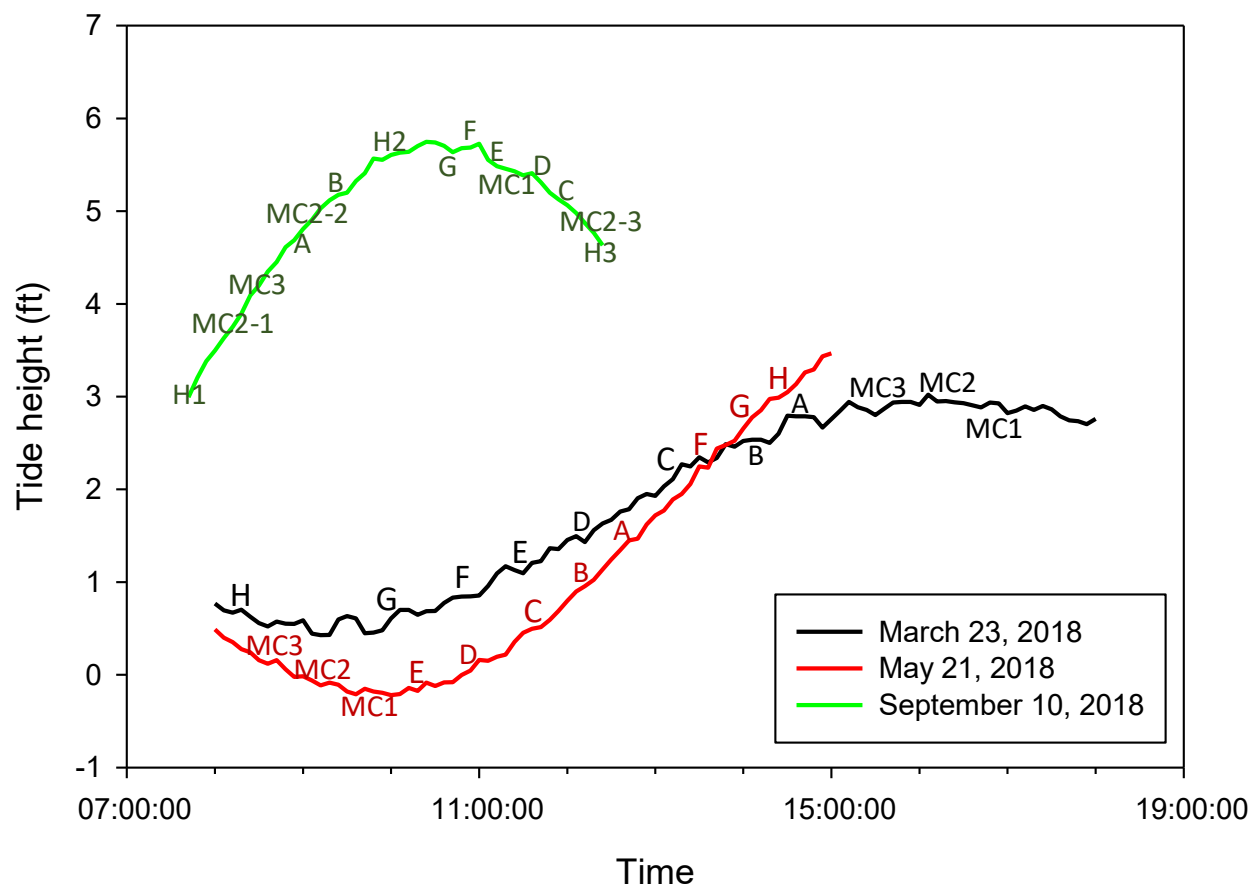


Figure 2. Tide height over the timeframe for each sample collection event: March (black), May (red), and September (green).

DOC and chlorophyll values were the most variable measures by time and depth when compared to temperature, pH, and DO. DOC was higher at most stations in the winter-wet weather event compared to the two dry weather events (Figure 3). The lowest DOC values were frequently in the front basins (A) or in the main channel near the mouth of the harbor (MC3). The location of higher DOC values was more variable, but they frequently occurred in the back basins. This pattern is likely due to water circulation patterns in the Harbor. Chlorophyll showed an increase in concentration from the first event to the second and third events. Chlorophyll concentrations also varied spatially with higher concentrations usually present in the back basins.

Both DOC and chlorophyll were significantly different over time. It was determined that for both DOC and chlorophyll, data from events 2 and 3 (both dry weather events) were different from event 1 (wet weather) but not different from each other. Significant differences by depth were found for DOC and chlorophyll for event 1 (wet weather) but not event 2 (dry weather). Because of the higher variability in time, depth, and space, DOC and chlorophyll may be important determinants of the critical condition.

Harbor average copper concentration was similar among sampling events. Dissolved copper concentrations were not significantly different over time or depth. For all three sampling events, dissolved copper concentrations were similar among most stations except for the main channel

stations in the front basin area (Figure 4). Dissolved copper concentrations at most stations exceeded the current water quality objective of 3.1 µg/L. Stations MdrRH-MC2 and -MC3 frequently had lower copper concentrations in surface and/or bottom water samples compared to samples from the rest of the Harbor. Surface concentrations during the winter-wet weather event tended to be higher than bottom concentrations, but these differences were not statistically significant.

Table 3. Harbor-wide average values for MdrRH water quality parameters by sampling event and depth. Data is presented as “average (coefficient of variation)”.

Sampling Event	Depth	Dissolved Copper (µg/L)	DOC (mg/L)	Chlorophyll (µg/L)	pH*	Salinity (ppt)	Temperature (°C)
1	Surface	6.64 (33)	1.10 (12)	1.72 (41)	7.93	33.22 (1.7)	16.97 (2.7)
	Bottom	4.70 (54)	0.94 (13)	3.69 (61)	7.95	33.90 (3.1)	16.73 (3.3)
	All	5.71 (44)	1.02 (15)	2.66 (71)	7.94	33.54 (2.6)	16.85 (3.0)
2	Surface	7.02 (17)	0.77 (20)	3.14 (42)	7.84	33.28 (0.38)	19.55 (3.4)
	Bottom	5.64 (47)	0.76 (23)	4.25 (63)	7.84	33.18 (0.18)	19.26 (4.4)
	All	6.36 (33)	0.77 (21)	3.67 (57)	7.84	33.23 (0.33)	19.41 (3.9)
3	Surface	5.71 (33)	0.84 (8.6)	3.10 (41)	7.94	34.07 (0.64)	22.45 (2.6)

*Average is based on hydronium ion (H₃O⁺) concentration and converted back to the log scale. As such, no CV is reported.

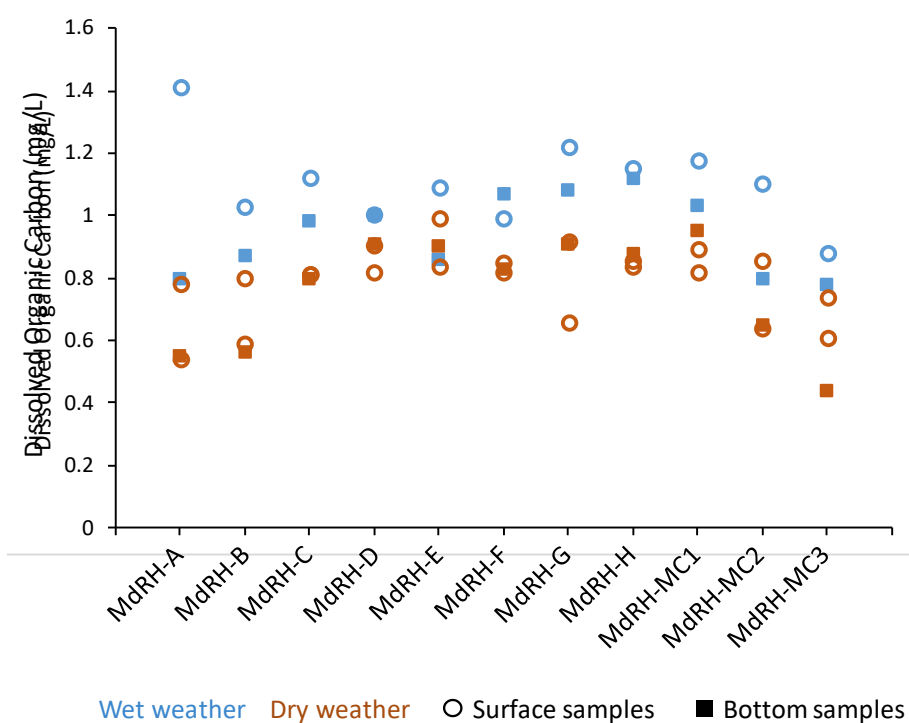


Figure 3. Dissolved organic carbon concentrations (mg/L) at each station by depth (surface=open circles, bottom=closed squares) and weather (wet=blue, dry=orange).

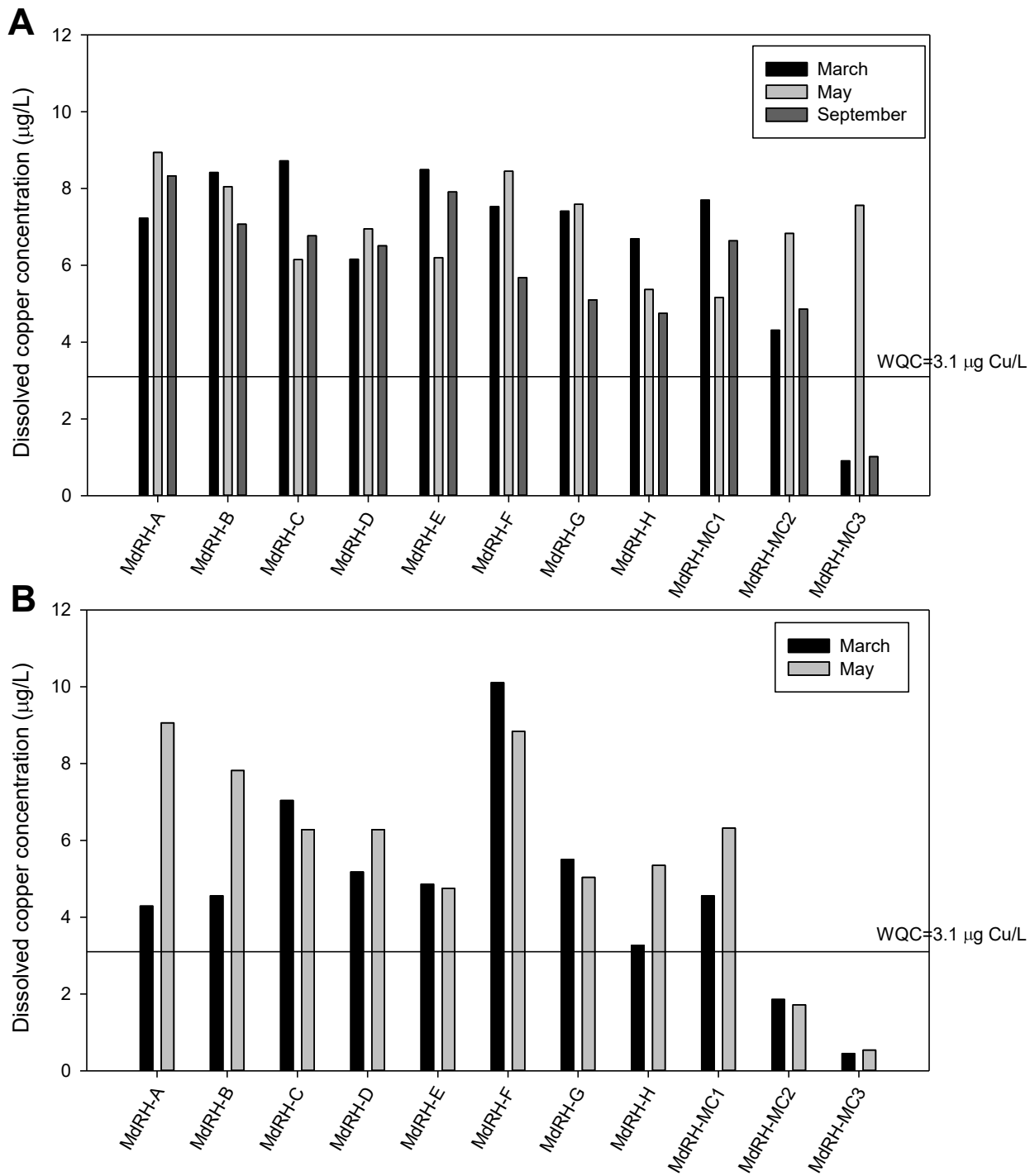


Figure 4. Dissolved copper concentration at each station over time in surface samples (A) and bottom samples (B).

Relationships Among Water Quality Parameters

Correlation analysis was performed for each sampling event to identify relationships between DOC (controlling factor for copper bioavailability) and tide height (as a measure of coastal water influx), chlorophyll, or copper. For the winter-wet weather event, no correlations were found for surface water samples. Bottom samples had a significant correlation ($p=0.015$) between tide height and DOC concentration. This is an inverse relationship where a higher tide height is related to lower DOC. This correlation is driven by low DOC in two of the main channel stations which were both sampled at high tide. Although this result is statistically significant, this depth-related trend may be an artifact of the station sampling sequence. The main channel stations, expected to have relatively low DOC due to greater mixing with offshore water, were sampled at the end of the day (highest tide height).

For the spring-dry weather event, there was no correlation between DOC and tide height. Surface samples had two significant correlations: a correlation ($p=0.031$) between dissolved copper and DOC concentration, and a correlation ($p=0.011$) between DOC concentration and chlorophyll concentration. The first is an inverse relationship where a higher DOC concentration is related to lower copper concentration, and the second is a direct correlation where a higher DOC concentration is related to a higher chlorophyll concentration. The bottom samples only had one significant direct correlation between DOC concentration and chlorophyll concentration ($p=0.002$).

For the summer-dry weather event, none of the parameters were significantly correlated with DOC. The lack of correlation may have been due to the narrow range of DOC values, as there is a minimal spread of data with which to observe a correlation.

Table 4. Summary of parameter correlations with DOC.

Depth	Parameter	DOC (mg/L)		
		March	May	September
Surface	Chlorophyll (ug/L)	-0.40 (0.19)	0.69 (0.011)*	0.20 (0.43)
	Tide height (ft)	-0.011 (0.96)	-0.37 (0.22)	-0.10 (0.69)
	Diss. Copper (µg/L)	0.32 (0.31)	-0.62 (0.031)*	0.41 (0.15)
Bottom	Chlorophyll (ug/L)	0.036 (0.90)	0.79 (0.002)*	
	Tide height (ft)	-0.70 (0.015)*	-0.077 (0.80)	
	Diss. Copper (µg/L)	0.50 (0.11)	0.011 (0.97)	

Data is presented as "correlation coefficient (p Value)". A negative correlation coefficient signifies an inverse relationship. *Denotes significance.

Short-term variability in water quality associated with tide height was investigated in the summer sampling event. Stations MdrRH-H and MdrRH-MC2 were sampled three times over the duration of the sampling event, with a duplicate sample taken during the second visit. Variability in DOC and chlorophyll was compared to results for the duplicate samples (i.e., sampling variability). DOC concentration in the repeated samples was more variable than in the duplicates for both stations (Figure 5). The highest DOC value was measured in the last sample collected, which represented an outgoing tide. The magnitude of the DOC change was relatively small, however.

Greater variability in the chlorophyll data was observed for the repeated samples (Figure 6). However, the range of concentrations among the repeated samples was similar to that for the duplicate, indicating little effect of tide height on the results.

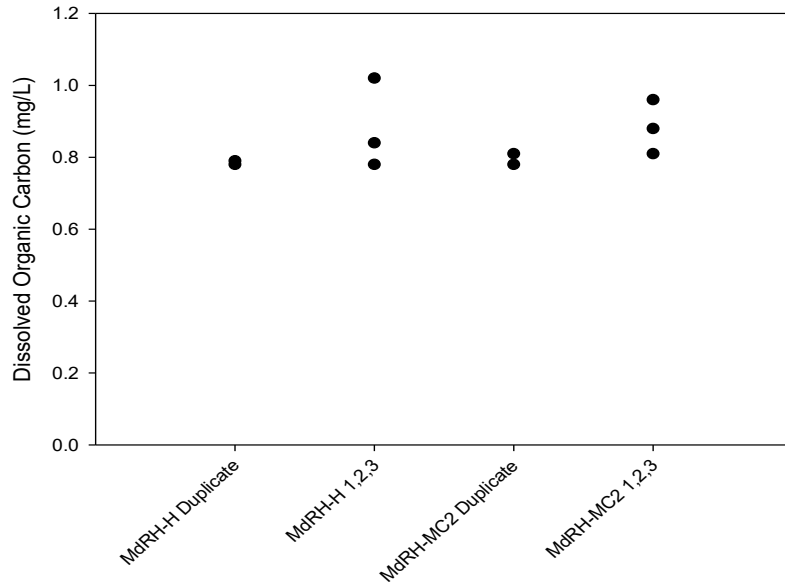


Figure 5. Dissolved organic carbon concentration (mg/L) as a function of duplicate and repeated measurements at stations MdRH-H and -MC2.

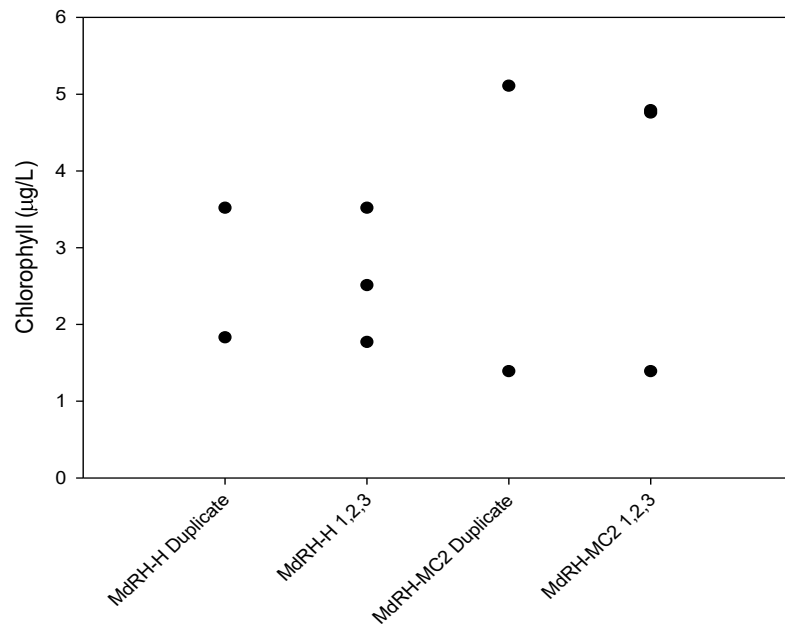


Figure 6. Chlorophyll concentration (mg/L) as a function of duplicate and repeated measurements at stations MdRH-H and -MC2.

Toxicity

Toxicity tests were performed on all samples collected, using the mussel embryo development test. All toxicity results are listed in the Appendix (Tables A1, A2, and A3). These data are used to better characterize MdrRH and determine the ambient toxicity in preparation for the WER study, but they are not required to determine the critical condition. The tests for events 1 and 2 met all applicable test performance criteria. The event 3 control (76% normal) fell below the control acceptability threshold of 90% normal. No definitive cause for the low control result was determined but may have been related to general difficulty in obtaining good quality spawning during the warmer summer months. As such, the toxicity results from September are uncertain.

Reference toxicity tests using copper were conducted for each round of testing and all resulting EC50 concentrations fell within two standard deviations of our control chart mean, indicating similar sensitivity of the organisms used in each test. The calculated EC50 value for events 1, 2, and 3 were 8.81 $\mu\text{g Cu/L}$, 8.23 $\mu\text{g Cu/L}$, and 7.33 $\mu\text{g Cu/L}$, respectively. Based on our control chart, these organisms have similar sensitivity to copper as seen in previous tests.

No toxicity was observed for samples from events 1 and 2 (Figure 7). Four stations from event 3 displayed high toxicity: MdrRH-B, -E, -F, and -MC1. These results ranged from 12.1-38.7% normal (control-adjusted). However, for all three events, no significant correlation was found between the toxicity test results and the dissolved copper concentrations; there were nontoxic samples from all three events with copper concentrations that were similar to those showing toxicity.

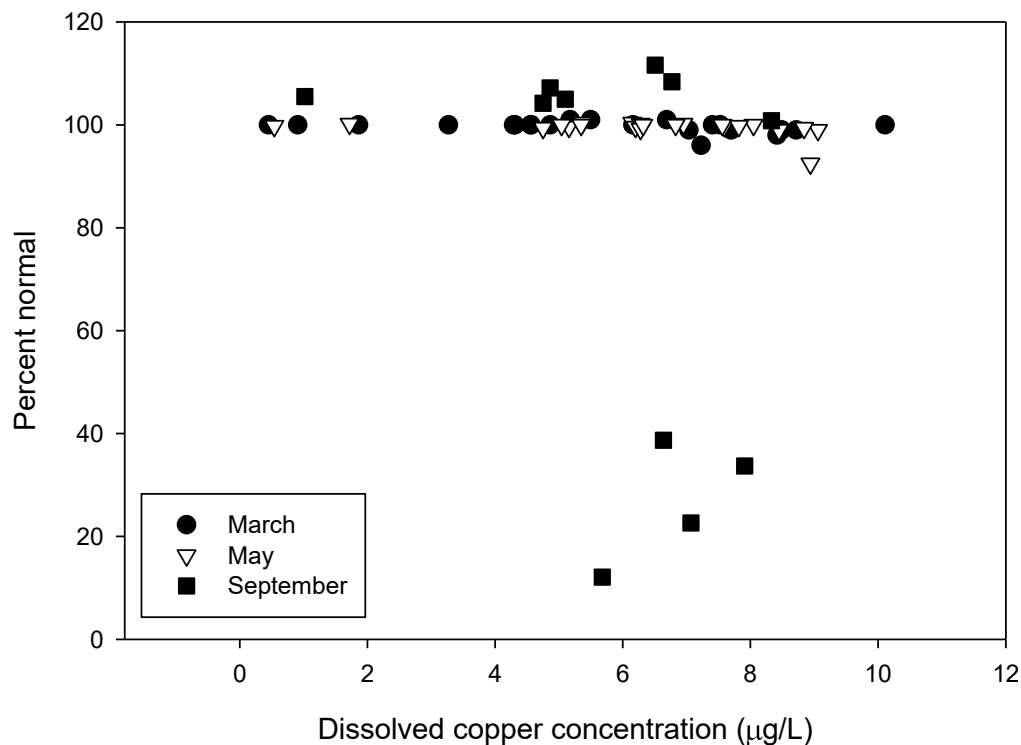


Figure 7. Toxicity as a function of dissolved copper concentration ($\mu\text{g/L}$) for the three sampling events: March (circles), May (triangles), and September (squares).

Biotic-Ligand Model Predictions

The Biotic Ligand Model developed for the draft EPA marine water quality criteria for copper was applied, utilizing the pH, temperature, salinity, and DOC data for each station for all three events. The BLM results provide a predicted acute EC50 concentration based on dissolved copper for *Mytilus galloprovincialis* (same species used in this study). The EC50 value is the concentration at which 50% of the organisms are affected. Thus, it is possible to see some toxicity in water samples with measured concentrations lower than the predicted EC50. The BLM EC50 provides a prediction of toxicity potential for copper, which can be used as another indicator of water quality conditions corresponding to the critical condition. The BLM predicted acute EC50 values were calculated for each station from all three sampling events. Predicted EC50 values ranged from 5.7 to 10.3 µg/L for event 1, 4.0 to 7.3 µg/L for event 2, and 5.8 to 7.6 µg/L for event 3.

Most of the event 1 samples had dissolved copper concentrations less than or equal to the predicted EC50 value (Figure 8A, B). This suggests that low or no toxicity is expected at those stations, which was consistent with the results of the toxicity test. No toxicity was observed for any sample. The results were more variable for event 2, with approximately half of the measured copper values greater than the predicted EC50 (Figure 8C, D). Based on these predictions, about half of the water samples would be expected to show toxicity. However, no toxicity was observed in any sample from event 2. Event 3 results were also variable with six of the measured values less than the predicted EC50 and seven of the measured values greater than the predicted EC50 (Figure 8E). Of the four samples that displayed toxicity, three had measured copper concentrations greater than the predicted EC50. Of the nine non-toxic samples, three of them had measured dissolved copper concentrations greater than the predicted EC50. Overall, 9 out of 13 toxicity test results matched with expectations based on the BLM predicted EC50 value and measured dissolved copper concentrations.

The lack of correspondence between BLM predictions and toxicity results is greater than expected (B. Santore, pers. Comm.), and no explanation is available at this time. Possible factors influencing the results include variations in the sensitivity of the toxicity test that are not identified from the reference toxicant test, toxicity due to materials other than copper, and presence of unmeasured factors influencing bioavailability. Additionally, the nature of the DOC may vary and influence the bioavailability of copper (De Schamphelaere et al. 2004; Nadella et al. 2009).

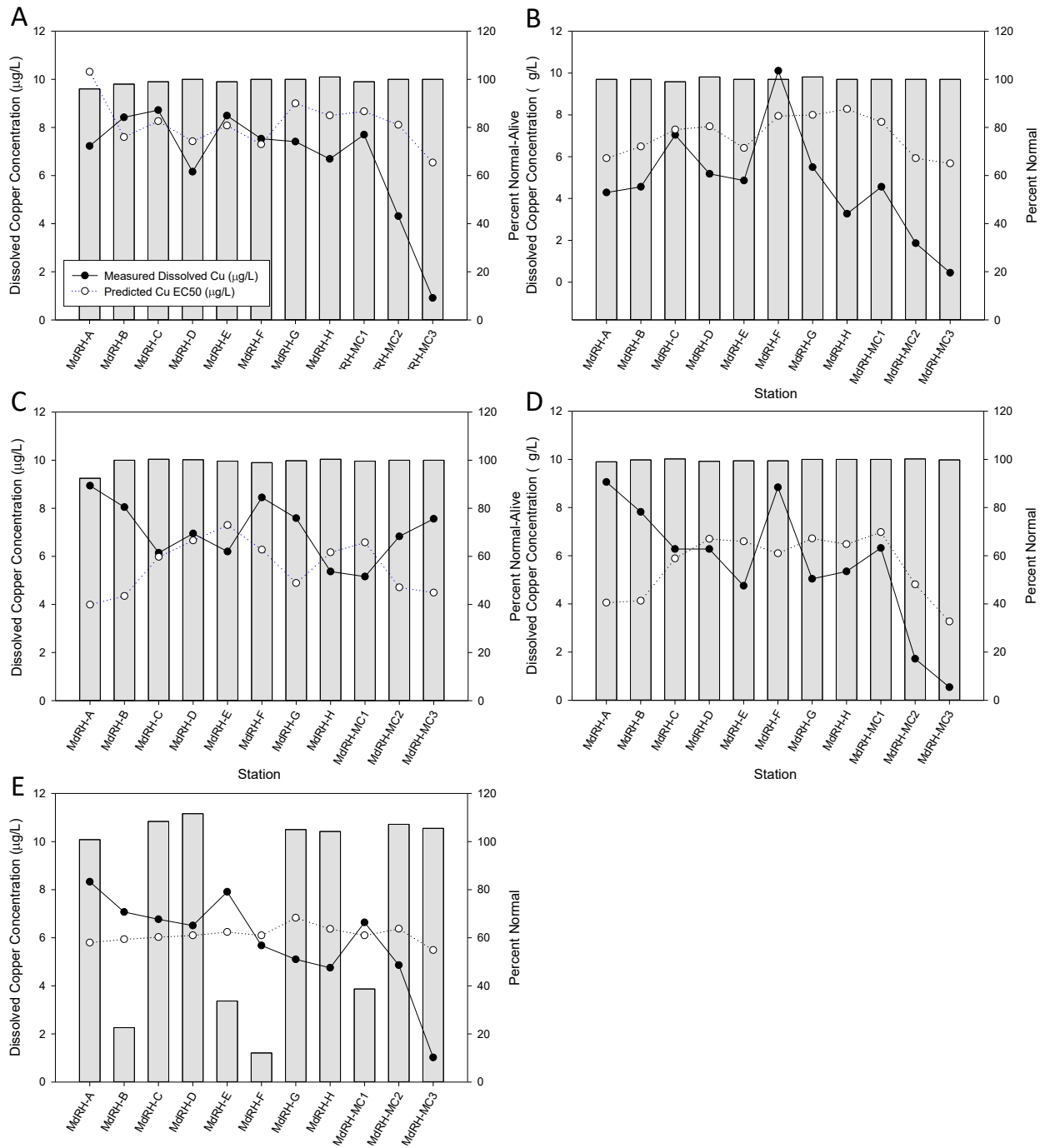


Figure 8. A comparison of the measured (black circles) dissolved copper concentration (µg/L) to the BLM predicted EC50 value (white circles, µg/L) and the toxicity test results (grey bars) for surface and bottom water samples from March (A and B), surface and bottom water samples from May (C and D), and surface water samples from September (E).

Summary

The critical condition is based on when copper bioavailability is expected to be highest, resulting in the greatest toxic potential to resident organisms. This study investigated the influence of nine water quality and other factors on bioavailability (Table 5). Three factors were identified as having the strongest influence on bioavailability: weather (e.g., presence of stormwater runoff), DOC, and location within the harbor. DOC is established in the scientific literature as having a dominant influence on copper bioavailability in marine waters, which supports the conclusion that DOC is a primary factor influencing the critical condition in MdrH. Wet weather conditions that result in stormwater runoff discharges to the harbor are likely to reduce copper bioavailability through an increase in DOC content. However, the nature of DOC input from stormwater may differ from the natural marina DOC which can alter the type of organic matter present between wet and dry events leading to differences in copper bioavailability.

Station location also had a strong influence on DOC content, and thus predicted bioavailability. Stations located near the front region of the harbor generally had the lowest DOC concentrations, possibly due to greater tidal exchange with offshore water having lower DOC. Station location was the factor with most consistent influence on DOC concentration for all three sampling events.

Tide stage and chlorophyll were shown to influence some water quality parameters and potentially bioavailability, but to a minor degree. Correlations between tide height and DOC or copper were occasionally present. However, the magnitude of variation associated with tide stage was similar to that observed among different station locations. Variation in chlorophyll was occasionally associated with DOC variability, likely due to variations in phytoplankton abundance in the harbor. This result indicates that bioavailability of copper may be reduced when phytoplankton blooms are present.

The copper and toxicity measurements made in this study do not directly influence conclusions about the critical condition, as they do not affect bioavailability. However, these parameters are important to developing a study design that includes both the critical condition and conditions representative of harbor locations where impacts are likely to occur. Copper concentrations were similar among most harbor stations located in basins, with the greatest variation apparently associated with seasonal factors. Toxicity to mussels was infrequent in this study, with most of the toxic stations located in the harbor back basins. Thus, a study design that includes back basin locations is likely to represent conditions where biological impacts from dissolved copper are greatest.

In summary, the critical condition (greatest copper bioavailability) is most likely to occur at harbor locations with the lowest DOC. DOC is expected to be lowest during dry weather periods throughout the year and at locations nearest the harbor entrance where water exchange is likely greatest (e.g., main channel and front basins). However, variations in water quality is also expected to occur because of other factors that are poorly understood or difficult to predict. Thus, sampling at multiple locations in the harbor, and over multiple time points, is needed to characterize variations in copper bioavailability.

It is recommended that a study design that includes multiple harbor locations and time points be used for water effect ratio determination in MdrH. Sampling at five locations, representing all

three main regions of the harbor, should be sufficient to capture the critical condition for copper variability, as well representing the breadth of harbor conditions for evaluation of a site-specific objective. The recommended station locations are shown in Figure 9.

Table 5. Summary of the effects of the various parameters on the critical condition.

Parameter	Effect on the Critical Condition?		
	Yes	No	Minor
Weather	X		
Tide height			X
Sampling depth		X	
Chlorophyll			X
DOC	X		
Temperature		X	
Salinity*		X	
pH*		X	
Station location	X		

*Data did not vary greatly over time or space. With these minor changes, no effect on critical condition was observed.

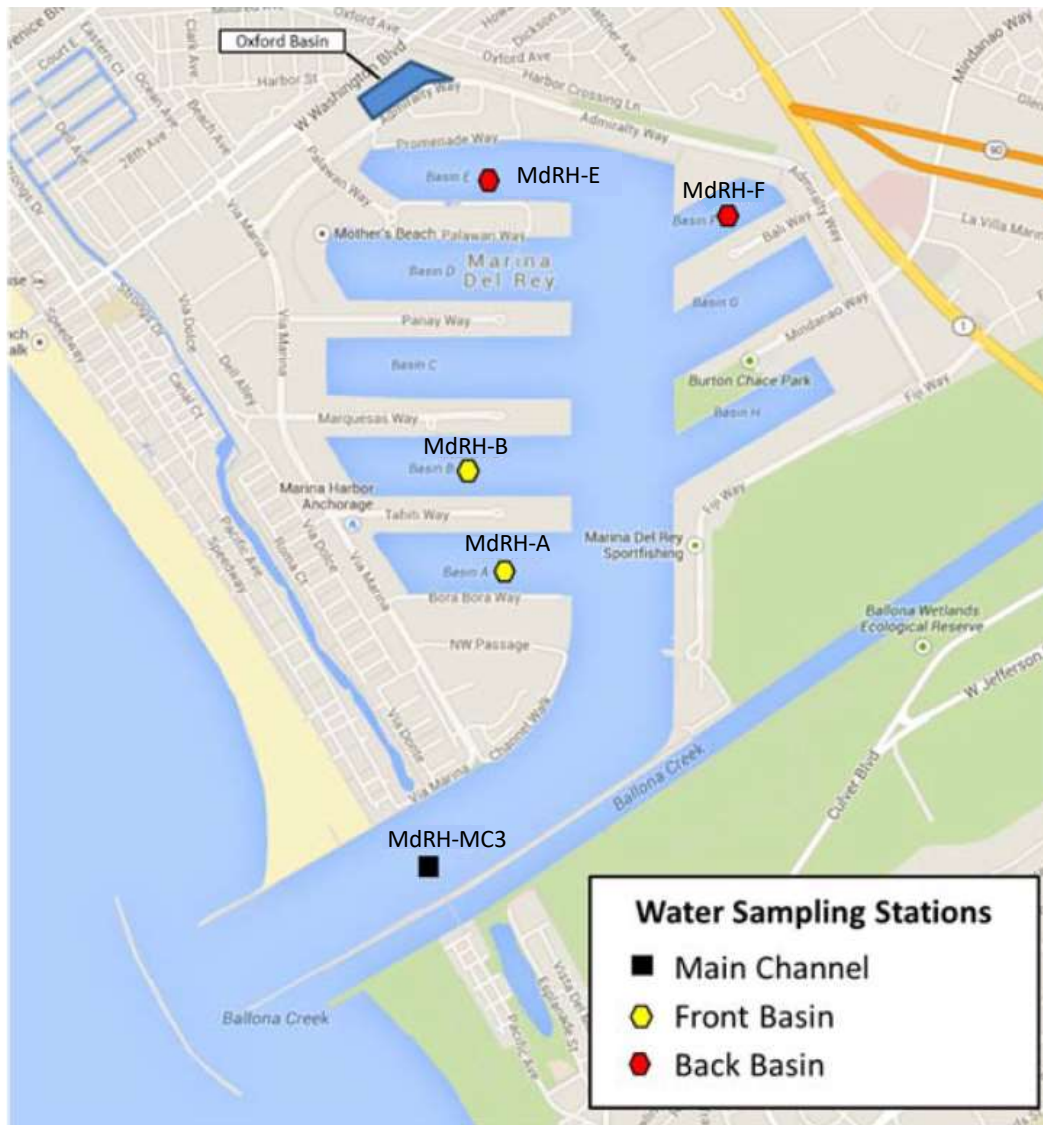


Figure 9. Proposed stations for WER analysis.

References

- Arnold, W.R., R.C. Santore, and J.S. Cotsifas. 2005. Predicting copper toxicity in estuarine and marine waters using the biotic ligand model. *Marine pollution bulletin*, 50: 1634-1640.
- De Schampelaere, K.A.C., F.M. Vasconcelos, F.M.G. Tack, H.E. Allen, and C.R. Janssen. 2004. Effect of dissolved organic matter source on acute copper toxicity to *Daphnia magna*. *Environ. Toxicol. Chem.*, 23: 1248-1255.
- Nadella, S.R., J.L. Fitzpatrick, N. Franklin, C. Bucking, D.S. Smith, and C.M. Wood. 2009. Toxicity of Cu, Zn, Ni, and Cd to developing embryos of the blue mussel (*Mytilus trossolus*) and the protective effect of dissolved organic carbon. *Comp. Biochem. Physiol. C*. 149: 340-348.
- United States Environmental Protection Agency (USEPA). 1994. Interim Guidance on the Determination and Use of Water-Effect Ratios for Metals. U.S. Environmental Protection Agency. EPA/823/B-94/001. Office of Science and Technology. Washington, DC. February 1994.
- USEPA. 1995. Short-term methods of estimating the chronic toxicity of effluents and receiving water to west coast marine and estuarine organisms. National Exposure Research Laboratory, Office of Research and Development. Cincinnati, Ohio.
- USEPA. 2001. Streamlined Water-Effect Ratio Procedure for Discharges of Copper. U.S. Environmental Protection Agency. EPA/822/R-01/005. Office of Water. Washington, DC.

Appendix: Site Characterization Data

Table A1. Data collected from the winter wet weather site characterization sampling event on March 23, 2018.

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
MdRH-A	Surface	1440	2.789	7.76	33.3	16.3	7.8	1.41	1.50	9.36	7.23	55.1	38.5	96.4	10.31
MdRH-A	Bottom	1440	2.789	7.97	33.4	16.5	7.8	0.80	2.01	4.91	4.29	35.1	24.0	100.5	5.93
MdRH-B	Surface	1408	2.536	7.93	32.9	17.5	7.7	1.03	0.88	9.43	8.42	52.2	42.5	98.0	7.60
MdRH-B	Bottom	1408	2.536	7.93	34.7	16.9	8.8	0.87	7.65	9.44	4.56	56.8	25.2	100.2	6.49
MdRH-C	Surface	1313	2.11	7.92	32.8	17.5	7.7	1.12	1.01	8.51	8.72	56.4	45.8	98.8	8.26
MdRH-C	Bottom	1313	2.11	7.94	34.5	17.4	7.8	0.98	1.80	8.24	7.04	49.6	39.3	99.2	7.30
MdRH-D	Surface	1212	1.43	7.90	33.1	17.2	7.8	1.02	2.53	8.51	6.58	56.4	38.3	100.2	7.53
MdRH-D-Dup	Surface	1212	1.43	7.88	33.4	17.5	7.4	0.99	3.12	7.82	5.74	48.6	34.7	100.6	7.32
MdRH-D	Bottom	1250	1.903	7.95	34.6	17.2	7.6	1.00	7.01	8.24	5.18	49.6	33.5	100.5	7.45
MdRH-E	Surface	1132	1.096	7.93	33.7	17.1	7.6	1.09	2.31	10.28	8.49	64.8	55.6	98.7	8.08
MdRH-E	Bottom	1132	1.096	7.87	35.0	17.1	7.0	0.86	4.42	7.10	4.86	52.4	33.6	100.2	6.42
MdRH-F	Surface	1050	0.843	7.98	32.9	16.9	7.4	0.99	1.84	8.89	7.53	48.3	37.4	99.6	7.30
MdRH-F	Bottom	1050	0.843	7.88	34.3	16.9	6.9	1.07	3.88	7.37	10.11	45.9	30.2	99.8	7.95
MdRH-G	Surface	1000	0.607	7.97	32.9	16.7	7.4	1.22	1.07	8.24	7.41	49.8	35.5	99.8	9.00
MdRH-G	Bottom	1000	0.607	7.98	33.7	16.8	7.9	1.08	2.72	6.41	5.50	39.9	28.7	100.7	8.00
MdRH-H	Surface	820	0.702	7.92	33.2	16.8	7.2	1.15	0.93	7.03	6.69	38.8	28.8	100.6	8.50
MdRH-H	Bottom	820	0.702	7.93	33.2	17.2	7.6	1.12	1.07	6.81	3.27	40.4	23.2	100.2	8.28
MdRH-MC1	Surface	1651	2.936	7.98	32.3	17.0	7.9	1.18	2.10	8.66	7.70	52.1	38.8	98.8	8.67
MdRH-MC1	Bottom	1651	2.936	7.98	34.4	16.4	8.2	1.03	5.69	6.97	4.56	45.4	29.7	99.8	7.66
MdRH-MC2	Surface	1620	2.953	8.05	33.5	17.0	8.2	1.10	1.41	5.32	4.31	37.3	24.8	100.0	8.11
MdRH-MC2	Bottom	1620	2.953	7.99	33.8	15.9	8.1	0.80	1.66	3.81	1.86	30.7	11.4	100.4	5.93
MdRH-MC3	Surface	1535	2.871	8.04	34.6	16.1	9.3	0.88	1.88	1.32	0.91	19.8	4.9	100.5	6.54
MdRH-MC3	Bottom	1535	2.871	8.07	31.3	15.7	8.8	0.78	2.71	0.83	0.45	17.3	4.1	99.6	5.68

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
QA samples															
Field Bk*										<0.005	0.03	17.9	0.878		
Travel Bk										<0.005	NA	<0.005	NA		
Tubing Bk										0.14	0.072	13	12.8		

Diss.-Dissolved

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

*The Field blank includes the use of the sample containers and syringe filter system.

Table A2. Data collected from the spring dry weather site characterization sampling event on May 21, 2018.

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
MdRH-A	Surface	1238	1.34	7.83	33.2	19.7	7.4	0.54	1.57	10.9	8.94	34.2	32.0	92.5	3.99
MdRH-A	Bottom	1246	1.47	7.82	33.1	19.3	7.0	0.55	2.05	12.0	9.06	34.0	31.3	99.0	4.05
MdRH-B	Surface	1211	0.96	7.83	33.1*	20.3	7.3	0.59	1.85	9.94	8.05	31.0	30.8	100.0	4.35*
MdRH-B	Bottom	1219	1.02	7.83*	33.1	19.8	7.2	0.56	2.50	9.45	7.82	30.8	29.1	99.8	4.13*
MdRH-C	Surface	1141	0.52	7.86	33.3	19.0	7.3	0.81	2.40	8.41	6.15	30.4	26.6	100.4	5.98
MdRH-C	Bottom	1152	0.69	7.82	33.2	19.7	6.7	0.80	5.38	8.35	6.28	29.5	26.7	100.2	5.89
MdRH-D	Surface	1053	0.05	7.83	33.2	19.5	7.1	1.00	2.87	13.0	6.71	42.3	34.1	100.0	7.36
MdRH-D-Dup	Surface	1105	0.15	7.83*	33.2*	19.5*	7.1*	0.81	5.55	11.1	7.19	39.7	35.3	100.4	5.97*
MdRH-D	Bottom	1115	0.19	7.83*	33.2	19.7	6.5	0.91	3.85	17.0	6.28	46.2	34.4	99.2	6.90*
MdRH-E	Surface	1019	-0.17	7.84	33.3	19.2	6.4	0.99	5.07	12.7	6.20	49.3	40.0	99.6	7.30
MdRH-E	Bottom	1031	-0.12	7.79	33.2	19.4	5.9	0.90	3.60	16.8	4.75	47.8	34.6	99.4	6.60
MdRH-F	Surface	1333	2.24	7.87	33.2	20.9	7.3	0.85	3.79	10.4	8.45	36.7	36.0	99.0	6.28
MdRH-F	Bottom	1339	2.44	7.81	33.1	20.3	6.8	0.83	5.09	10.3	8.84	39.0	40.4	99.4	6.10
MdRH-G	Surface	1400	2.66	7.93	33.3	20.1	7.1	0.66	2.04	9.68	7.59	31.9	30.9	99.8	4.89
MdRH-G	Bottom	1408	2.78	7.86	33.2	19.6	7.9	0.91	10.39	6.91	5.04	21.2	22.3	100.0	6.72
MdRH-H	Surface	1426	2.99	7.79	33.2	19.8	7.1	0.84	3.44	8.79	5.37	30.5	22.4	100.4	6.17
MdRH-H	Bottom	1437	3.14	7.81	33.3	19.4	7.0	0.88	4.21	7.08	5.35	24.2	22.5	100.0	6.48
MdRH-MC1	Surface	0949	-0.18	7.86	33.4	19.3	6.6	0.89	3.88	9.79	5.16	38.7	24.3	99.6	6.58
MdRH-MC1	Bottom	0959	-0.22	7.81	33.2	19.2	6.5	0.95	6.80	8.32	6.32	32.3	30.2	100.0	6.98
MdRH-MC2	Surface	0917	-0.08	7.79	33.5	18.6	6.8	0.64	3.63	8.47	6.83	33.2	28.6	100.0	4.71
MdRH-MC2	Bottom	0928	-0.18	8.01	33.2	18.3	6.9	0.65	2.15	4.21	1.72	11.8	6.79	100.2	4.81
MdRH-MC3	Surface	0840	0.16	7.80	33.5*	18.7	5.4	0.61	1.62	9.10	7.56	29.8	29.1	100.0	4.49*
MdRH-MC3	Bottom	0854	-0.02	7.92	33.2*	17.2	5.6	0.44	0.76	1.48	0.541	3.63	2.14	99.8	3.27*

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
QA samples															
Field Bk**										<0.005	<0.005	<0.005	0.202		
Travel Bk										<0.005	<0.005	<0.005	<0.005		
Tubing Bk										0.118	<0.005	19.5	2.26		

Diss.-Dissolved

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

*Main salinity meter was giving values which seemed very high. A second, uncalibrated unit that was giving more reasonable values was used at the remaining sites. Missing values were completed using the other field measurement (surface or bottom) as there was little observed difference. These values were used in the calculation of the BLM Predicted FAV.

**The Field blank includes the use of the sample containers and syringe filter system.

Table A3. Data collected from the summer dry weather site characterization sampling event on September 10, 2018.

Station	Depth	Sample Time	Tide (ft)	pH*	Salinity* (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀ *
MdRH-A	Surface	0851	4.69	7.90	34.1	22.1	7.1	0.78	1.36	10.1	8.33	39.0	36.9	100.8	5.80
MdRH-B	Surface	0925	5.18	7.90	34.0	22.4	7.8	0.80	4.15	8.45	7.07	32.9	30.8	22.6	5.94
MdRH-C	Surface	1157	5.13	7.90	34.2	23.0	7.1	0.81	3.56	7.71	6.77	32.4	30.1	108.4	6.03
MdRH-D	Surface	1139	5.41	7.89	34.4	23.1	7.1	0.82	4.08	9.37	6.51	39.3	35.5	111.6	6.10
MdRH-E	Surface	1112	5.49	7.88	34.0	23.0	7.0	0.84	2.55	9.80	7.91	51.5	48.9	33.7	6.24
MdRH-F	Surface	1057	5.69	7.92	34.0	23.0	7.0	0.82	2.70	8.90	5.68	30.9	26.9	12.1	6.10
MdRH-G	Surface	1041	5.64	7.91	34.0	22.7	7.7	0.92	4.40	6.67	5.10	25.2	23.2	105.0	6.83
MdRH-H-1	Surface	0744	3.00	7.98	33.9	22.2	6.5	0.84	1.77	NA	NA	NA	NA	NA	6.24
MdRH-H-2	Surface	1001	5.61	7.93	34.1	22.4	7.6	0.78	3.52	6.91	4.87	23.8	21.4	102.6	5.80
MdRH-H-2 Dup	Surface	1010	5.64	8.03	33.8	22.4	7.3	0.79	1.83	6.44	4.63	23.7	22.1	105.8	5.86
MdRH-H-3	Surface	1225	4.63	7.99	34.3	22.6	7.7	1.02	2.51	NA	NA	NA	NA	NA	7.58
MdRH-MC1	Surface	1125	5.43	7.92	34.1	22.9	7.4	0.82	1.68	8.41	6.64	34.7	31.0	38.7	6.10
MdRH-MC2-1	Surface	0812	3.75	7.98	34.6	22.2	7.7	0.88	4.76	NA	NA	NA	NA	NA	6.56
MdRH-MC2-2	Surface	0903	4.91	7.95	34.0	22.1	7.8	0.81	1.39	6.14	4.96	23.4	23.6	104.7	6.02
MdRH-MC2-2 Dup	Surface	0911	5.03	7.94	33.9	22.2	7.7	0.78	5.11	5.85	4.76	24.1	20.9	109.7	5.80
MdRH-MC2-3	Surface	1213	4.87	8.03	34.1	22.7	8.3	0.96	4.79	NA	NA	NA	NA	NA	7.12
MdRH-MC3	Surface	0828	4.20	7.96	33.7	20.6	7.9	0.74	2.53	1.42	1.02	5.68	4.09	105.5	5.49
QA samples															
Field Bk**										<0.005	<0.005	1.34	2.44		
Travel Bk										<0.005	<0.005	<0.0025	<0.0025		
Tubing Bk										0.755	0.376	10.9	18.5		

Diss.-Dissolved DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

NA-Not Analyzed

*Salinity and pH meters were not functional in the field. Data were recorded in the laboratory on September 11, 2018 using water samples collected from the field.

**The Field blank includes the use of the sample containers and syringe filter system.

APPENDIX B: WORKPLAN AND QAPP

FINAL WORK PLAN

MARINA DEL REY HARBOR SITE-SPECIFIC OBJECTIVE STUDY

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
BLM	Biotic Ligand Model
CCC	Criterion Continuous Concentration
CIMP	Coordinated Integrated Monitoring Program
COC	chain-of-custody
CTR	California Toxics Rule
DOC	dissolved organic carbon
DQO	data quality objective
EC50	median effective concentration
fWER	final Water-Effect Ratio
LACDBH	Los Angeles County Department of Beaches and Harbors
LACPW	Los Angeles County Public Works
MdR Harbor	Marina del Rey Harbor
µg/L	microgram per liter
mL	milliliter
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RWQCB	Regional Water Quality Control Board
SSO	site-specific objective
sWER	sample Water-Effect Ratio
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
Toxics TMDL	Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor
USEPA	U.S. Environmental Protection Agency
WER	Water-Effect Ratio

1 INTRODUCTION

The Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor (Toxics TMDL; Los Angeles RWQCB/USEPA 2013) includes load allocations for dissolved copper inputs to Marina del Rey Harbor (MdR Harbor). This section provides a brief overview of the regulatory background for MdR Harbor that led to the inclusion of dissolved copper water column targets in the revised Toxics TMDL and also discusses the rationale and background for using a site-specific objective (SSO) study to develop a scientifically defensible water quality criterion that accounts for site-specific conditions and focuses on the protection of aquatic life in the MdR Harbor.

1.1 Regulatory Background

In 1998, the back basins of MdR Harbor were placed on the 303(d) list for contaminants impacting sediment, fish tissue, and benthic infauna. At this time, pollutants of concern for sediment included DDT, chlordane, lead, copper, and zinc and pollutants of concern for fish tissue included those for sediment and PCBs, dieldrin, and tributyltin (TBT). The MdR Harbor Toxics TMDL was promulgated in 2005 to address impairments associated with sediment for copper, lead, zinc, chlordane, PCBs, and toxicity and fish tissue for DDT, dieldrin, chlordane, PCBs, and fish consumption advisory (Los Angeles RWQCB/USEPA 2005). Monitoring and special studies conducted in support of the Toxics TMDL have since provided additional information regarding the spatial extent and magnitude of the impairments; the special studies include partitioning coefficient, a low detection level, storm-borne sediment pilot, sediment characterization and BMP effectiveness studies. The results have shown that dissolved copper concentrations frequently have exceeded the chronic (4-day average) criterion (also referred to as Criterion Continuous Concentration [CCC]) of 3.1 micrograms per liter ($\mu\text{g/L}$), as specified in the California Toxics Rule (CTR).

The Toxics TMDL was revised and adopted by the Los Angeles Regional Water Quality Control Board (RWQCB) in February 2014 (Los Angeles RWQCB 2014) and was subsequently approved by the State Water Resources Control Board (SWRCB) in September 2014 (SWRCB 2014). Toxics TMDL revisions were designed to take into consideration new data on the spatial extent and magnitude of sediment contamination as well as address the dissolved copper CTR exceedances in the water column. As such, the Toxics TMDL includes load allocations for dissolved copper required to ensure that dissolved copper concentrations in MdR Harbor are less than the CCC criterion in the CTR.

In SWRCB Resolution 2014-0049 (SWRCB 2014), the SWRCB recognizes that the U.S. Environmental Protection Agency (USEPA)-approved Water-Effect Ratio (WER) method may be used to derive site-specific water quality objectives and if adopted by the Los Angeles RWQCB and approved by the SWRCB Office of Administrative Law and

USEPA will supersede the current CTR CCC criterion as the water quality standard for dissolved copper in MdR Harbor. Conditional approval to conduct an SSO study for Marina del Rey Harbor was granted by the Los Angeles RWQCB in September 2017 (revised in June 2018).

1.2 Development of Site-specific Objectives

Although there are exceedances of the dissolved copper CCC in MdR Harbor, the concentration threshold necessary to protect aquatic life in MdR Harbor is uncertain. It is well known that water quality parameters (e.g., pH, dissolved organic carbon [DOC], and salinity) influence the biological availability of copper in marine water and may reduce the potential to cause toxicity to aquatic life (USEPA 1994; Di Toro et al. 2001). It is possible that site-specific parameters can also lead to an increase in bioavailability/toxicity. As such, a $WER > 1$ indicates the environmental conditions reduce toxicity; a $WER < 1$ indicates an increase in toxicity; and a $WER = 1$ indicates no site-specific change to toxicity. The federal water quality criteria (from which the CTR criteria were derived) for dissolved copper were developed to be conservative in order to protect marine aquatic life in all waters of the U.S. regardless of site-specific water characteristics. Specifically, water quality criteria were developed based on laboratory studies in which filtered seawater was used, and consequently, these studies do not necessarily account for many of the physical constituents (e.g., particulate and dissolved organic matter) that may interfere with the toxicity of potential chemicals of concern, such as copper. Consequently, the USEPA has developed procedures that can be performed to develop water quality criteria that are specific and reflective of site-specific conditions, while still providing the required level of protection for aquatic life. The current water quality criteria (CCC and CMC) for copper are designed to be protective of the most sensitive species (*Mytilus sp.*). Because the WER represents an adjustment of the copper toxicity threshold in the field sample to match the toxicity of copper in laboratory water, the margin of safety intended in the original criteria is maintained.

The *Interim Guidance on Determination and Use of Water-Effect Ratios for Metals* (USEPA 1994) provides guidance for determining SSOs. This guidance includes three options: 1) the recalculation procedure; 2) the WER procedure; and 3) the resident species procedure. The recalculation procedure is intended to account for relevant differences between the sensitivities of the aquatic organisms in the national dataset and the sensitivities of organisms that occur at the site. The WER approach compares the toxicity of copper dissolved in different water types to determine an adjustment factor for the water quality standard. The resident species procedure is intended to account for differences in resident species sensitivity to biological availability and/or toxicity of a material due to variability in physical and chemical characteristics of the site water. In this study, the WER procedure is most appropriate and will be calculated based on tests with the most sensitive resident species in MdR Harbor. There are insufficient new data for the recalculation procedure and there are no threatened or

endangered species, negating the need to account for additional sensitive resident species.

The Biotic Ligand Model (BLM) is another USEPA-approved approach for determining site-specific criteria for dissolved metals in freshwater environments (Di Toro et al. 2001; Santore et al. 2001). A marine version of the BLM is currently under review by the USEPA but has not yet been approved. Nonetheless, some testing in marine environments has been performed to evaluate the BLM's ability to predict toxicity at marine sites throughout the United States (Arnold et al. 2005). Results have shown that the BLM can provide an accurate prediction of copper toxicity to sensitive marine taxa in marine receiving waters and that the BLM-predicted toxicity is strongly correlated with measured toxicity. The BLM approach requires only chemical and physical water quality data as inputs and consequently is a more cost-effective and less time-consuming method than the toxicity-based WER. Because of its efficiency, the BLM may allow for the examination of a wider range of site-specific conditions than could be captured during WER studies as well as evaluation of effectiveness of various management strategies. As such, the BLM will be used as a tool to provide additional data interpretation and comparison to the toxicity-based WER results. Ultimately, any proposed SSO will be based on the toxicity-based WER data alone.

In this study, WER procedures that are consistent with the USEPA (1994) Interim Guidance¹ will be used to calculate SSOs for Mdr Harbor that are scientifically defensible and protective of beneficial uses. The BLM was used during the site characterization evaluation to support the determination of environmental conditions likely to result in the lowest copper bioavailability. The results of this analysis suggested dissolved organic carbon (DOC) is an important site-specific parameter related to predicted copper toxicity. As such, additional DOC analysis has been added to the monthly TMDL monitoring program to further characterize the Harbor during the period of this study.

1.2.1 Water-Effect Ratio

The USEPA recommends calculating a WER to account for site-specific bioavailability and toxicity of contaminants (USEPA 1994). As part of a WER study, two side-by-side toxicity tests are conducted; one test uses laboratory dilution (clean) water and the other test uses site (contaminated) water. The WER is determined by calculating the ratio of the median effective concentration (EC50) values from the two tests as shown in Equation 1:

¹The USEPA also published a streamlined procedure for the WER development for copper in freshwater (USEPA 2001). The streamlined procedure provides simplified WER testing specific to a waterbody where a continuous point source, such as publically owned treatment works, primarily contributes to an elevated level of copper. The streamlined WER guidance is not applicable to Mdr Harbor due to differences in salinity and source of copper.

$$\text{WER} = \frac{EC50 \text{ Site water}}{EC50 \text{ Control or Reference water}} \quad (1)$$

The WER is then multiplied by the national or state aquatic life criterion; in this study, the CTR CCC (to represent chronic conditions) criterion will be used. Unlike in freshwater, the marine CCC is not hardness dependent.

To calculate SSOs, the WER is multiplied by the water quality criteria as shown in Equation 2:

$$\text{Chronic SSO} = \text{WER} \times \text{CCC} \quad (2)$$

The WER developed in this study will be appropriate for adjustment of the CCC, as specified in the EPA interim guidance.

1.2.2 Biotic Ligand Model

The BLM is a computational model used to predict metal speciation, complexation, and toxicity to aquatic organisms using site-specific water characteristics (Di Toro et al. 2001; Santore et al. 2001). The BLM was originally designed to estimate copper toxicity in freshwater fish and invertebrates; however, it has been used successfully in estuarine systems as well (Arnold et al. 2005; Chadwick et al. 2008). The BLM is based on the premise that both metal–ligand binding and metal interaction with competing cations may affect toxicity (Di Toro et al. 2001). Thus, the degree of toxicity is expected to be related to the amount of metal available to bind to the biotic ligand, the concentration of other aqueous ligands such as organic matter that can bind up the metal of concern, and the availability of other cations (i.e., calcium), which may have a protective effect.

The marine version of the BLM uses water chemistry parameters (e.g., pH, DOC, and salinity) to calculate bioavailable metals concentrations in water and metal binding affinity to biotic ligands. The BLM then predicts metal toxicity to aquatic organisms based on these calculations and outputs EC50 values (USEPA 2016a). For this study, the marine BLM for copper in saltwater developed by Robert Santore (Version 3.16.2.41 from Windward Environmental, LLC), which is currently under review for use by the USEPA in setting water quality criteria, will be used.

A BLM-based WER can be calculated using the BLM-predicted EC50 outputs for both site water and control or reference (clean) water as shown in Equation 3:

$$\text{BLM-based WER} = \frac{\text{BLM-predicted EC50 Site Water}}{\text{BLM-predicted EC50 Control or Reference Water}} \quad (3)$$

BLM-based SSOs may then be calculated using Equation 2 in Section 1.2.1. The Marine Copper BLM has been used by the EPA in the development of draft revised aquatic life ambient marine/estuarine water quality criteria (USEPA 2016b), but these

criteria have not yet received final approval. For this study, toxicity endpoints generated using the BLM will be used as a point of comparison to enhance interpretation of the study results.

1.2.3 Previous Marine or Estuarine Water-Effect Ratio Studies

While WER studies have been performed in freshwater environments nationwide, only a few WER studies conducted in California marine or estuarine waters are publicly available at this time. Only two marine/estuarine WER studies in California have resulted in SSOs that were adopted by a RWQCB and approved by the SWRCB. For other studies conducted in the marine environment, the status of adoption by the relevant RWQCB is currently unknown (LWA 2006) or the goal of the study was to better understand bioavailability of copper to aquatic organisms, as in Rosen et al. (1995) and Bosse et al. (2014), but not to develop an SSO. The most relevant studies are summarized below.

1.2.3.1 Lower South San Francisco Bay (South of Dumbarton Bridge)

An impairment assessment study for copper (and nickel) was conducted for Lower South San Francisco Bay (Tetra Tech et al. 2000). WER testing was a key part of this study and was used to understand how site-specific water quality parameters affect the bioavailability and toxicity of dissolved copper within the Lower South San Francisco Bay. The blue mussel *Mytilus edulis* and the purple sea urchin *Strongylocentrotus purpuratus* were used in this testing as primary and secondary species, respectively. Samples were collected from three sites in South San Francisco Bay, and tests were conducted from January 1996 to March 1997 to understand the temporal variability in bioavailability of Lower South San Francisco Bay waters. Results of this study demonstrated WER values ranging from 2.7 to 3.5 for dissolved copper. SSOs ranging from 6.7 to 8.8 µg/L for dissolved copper were then calculated using a modified CCC of 2.5 µg/L, based on toxicity test data collected as part of the study. A proposed SSO of 6.9 µg/L was recommended by the City of San Jose, based on pooled WER results from two stations and was suggested to be protective of the most sensitive species, *M. edulis*. An SSO of 6.9 µg/L was adopted by the San Francisco Bay RWQCB in 2002 (San Francisco Bay RWQCB 2002).

1.2.3.2 San Francisco Bay (North of Dumbarton Bridge)

A WER study was conducted in San Francisco Bay in 2000/2001 for purposes of developing copper SSOs for San Francisco Bay regions north of the Dumbarton Bridge (Clean Estuary Partnership 2005; San Francisco Bay RWQCB 2007a). Sampling was conducted at 13 stations that were selected based on stations previously sampled by the Regional Monitoring Program. The study involved sampling and WER testing during two dry seasons (September 2000 and June 2001) and two wet season (January and March 2001) events. Copper toxicity tests were performed using the bivalve *M. edulis* mussel development test. Results did not demonstrate a seasonal pattern in WERs;

however, differences in WERs across San Francisco Bay regions were measured and were likely due to differences in the physicochemical characteristics of water from different regions of San Francisco Bay. The geometric mean WERs for the San Francisco Bay regions north of San Bruno Shoal (i.e., north of Oakland airport on the eastern side and north of Little Coyote Point on the western side) ranged from 2.40 to 2.49 and the geometric mean WER for the region south of San Bruno Shoal was 2.90. Based on these findings, the Basin Plan Amendment proposed chronic and acute copper SSOs of 6.0 and 9.4 µg/L, respectively, for the area north of San Bruno Shoal and chronic and acute copper SSOs of 6.9 and 10.8 µg/L, respectively, for the region south of San Bruno Shoal. These SSOs were adopted by the San Francisco Bay RWQCB in 2007 (San Francisco Bay RWQCB 2007b).

1.2.3.3 San Diego Bay Studies

Rosen et al. (2005) evaluated the bioavailability of copper to organisms in the San Diego Bay. Water samples included composite and grab samples that were collected from various locations inside the bay from 2000 to 2002. Bivalve *Mytilus galloprovincialis* and echinoderm *S. purpuratus* or *Dendraster excentricus* embryos were used in WER toxicity tests. For WER calculations, EC50s from the copper-spiked San Diego Bay water samples (from various areas of the Bay) were compared to those from toxicity tests of copper-spiked reference seawater, which was filtered (0.45 micron) coastal seawater collected from the research pier at Scripps Institute of Oceanography. Estimates of the dissolved copper WER ranged from 1.54 to 1.67. These findings of WERs greater than 1 in San Diego Bay suggest that an SSO ranging from 4.7 to 5.2 µg/L (based on the WER range above) would be protective of the organisms throughout San Diego Bay.

More recently, a study of the bioavailability and toxicity of copper was conducted in Shelter Island Yacht Basin, a marina in North San Diego Bay (Bosse et al. 2014). As part of this study, WER sampling and testing was conducted in conjunction with copper complexation capacity measurements and modeling using the marine BLM. Samples were collected at two depths (near surface and near bottom) during two sampling events, representing the wet season and the dry season. Sampling for ambient toxicity occurred at 15 to 16 stations during each event, and samples from four of these stations were spiked with copper for use in WER testing. *M. galloprovincialis* embryos were used as the test species as part of the standard mussel development test (USEPA 1995). Results of this study demonstrated slightly lower WERs in the wet season (geometric mean of 1.2 ± 0.1) than in the dry season (geometric mean of 1.5 ± 0.2) with a final dissolved copper WER for all events of 1.33. These findings suggest that an SSO of 4.11 µg/L would be protective of marine organisms in the Shelter Island Yacht Basin.

1.2.3.4 Mugu Lagoon and Lower Calleguas Creek, Ventura County

A WER study for copper was conducted for Mugu Lagoon and Lower Calleguas Creek (LWA 2006) in accordance with the USEPA (1994) Interim Guidance. However, only the results for Mugu Lagoon, which is a marine environment, are relevant to the current study and are summarized here. Samples were collected during dry weather conditions in August 2003 and January 2004 and wet weather conditions in March 2004 and April 2006. *M. edulis* were the primary test species, and the larval bivalve development test was used to evaluate copper toxicity. The recommended WER for dissolved copper in Mugu Lagoon was determined to be 1.51, resulting in a chronic SSO established as 4.68 µg/L (LWA 2006).

1.2.3.5 Summary of Previous Water-Effect Ratio Studies

All studies summarized above have demonstrated that WER results were greater than 1. WER findings from these studies ranged from 1.33 in Shelter Island Yacht Basin to 3.5 in Lower South San Francisco Bay. SSOs estimated from these WER results range from 4.11 to 8.8 µg/L; however, to date, only the San Francisco Bay SSOs (ranging from 6.9 to 10.8 µg/L) have been adopted by the RWQCB (San Francisco Bay RWQCB 2002). These findings demonstrate that at each of these sites, a higher copper concentration than the current CTR CCC criterion of 3.1 µg/L would be protective of marine aquatic life and beneficial uses of those sites.

1.3 Previous Relevant Studies and Data in Marina del Rey Harbor

1.3.1 Dissolved Copper in Marina del Rey Harbor (Summary of CIMP data)

The Marina del Rey Coordinated Integrated Monitoring Program (CIMP) is a requirement of the Toxics TMDL in MdR Harbor. In the 2017-2018 monitoring year, wet and dry weather samples were collected. The wet weather sampling occurred at a main channel location near the back basins on January 9th and March 2nd-3rd, 2018. Both samples exhibited toxicity in the sea urchin fertilization test and the results of a Toxicity Identification Evaluation (TIE) indicated that cationic metals were likely responsible. Two additional main channel samples collected in 2017-2018 were also toxic in the sea urchin fertilization test. During dry weather, the main channel station is sampled monthly and several basins are sampled on a rotating schedule with each basin sampled every other month for copper analysis. Dissolved copper concentrations often exceeded the water quality criterion in dry weather sampling conducted to date.

1.3.2 DPR Copper Level Study

In 2006, the California Department of Pesticide Regulation performed a monitoring study in 23 marinas statewide, including freshwater, brackish water, and marine environments. Several samples from each marina were collected and analyzed for water quality parameters (salinity, temperature, DOC, pH, etc.), as well as total and dissolved copper and zinc, and toxicity (DPR 2009). The freshwater BLM was adapted

for use with the brackish and marine samples (under the guidance of Robert Santore, Windward Environmental, Syracuse, NY) to compare predicted toxicity to observed toxicity test results. The MdR Harbor samples exhibited the highest metals concentrations of all the marinas tested. Dissolved copper concentrations ranged from 8.1-18.4 µg/L in the back basins (BB) and 8.9-16.2 µg/L in the front basins (FB), total copper concentrations ranged from 9.0-20.2 µg/L (BB) and 9.2-17.2 µg/L (FB), and dissolved zinc concentrations ranged from 33.3-59.5 µg/L (BB) and 38.2-66.6 µg/L (FB). The DOC concentrations throughout the Harbor ranged from 0.69 mg/L to 1.90 mg/L.

Of the 47 samples tested for toxicity, 8 were toxic and 7 of those were from MdR Harbor. The toxicity at these stations ranged from 4-67 percent normal-alive mussel embryos. A Toxicity Identification Evaluation was performed on two of the samples from MdRH and it indicated that a cationic metal was responsible for the toxicity. Based on the measured copper and zinc concentrations, copper was likely the cause of the observed toxicity. These results aligned with the predicted toxicity based on the BLM. Overall, the BLM results for the marine samples were in good agreement with the observed toxicity (88% success rate).

1.4 Study Objective

The objective of this study is to develop a scientifically defensible SSO for MdR Harbor that accounts for site-specific conditions and is as protective of aquatic life and the beneficial uses of MdR Harbor as the current criteria.

2 STUDY DESIGN AND METHODS

This section comprises the WER study design and includes the details of the sampling program, analytical methods, and data analysis. The overall approach is based on the USEPA (1994) Interim Guidance for determining water effects ratios for metals. As stated in this guidance, development of WERs for surface waters (e.g., bays and harbors) located away from effluent plumes (Method 2) is a more complex and variable situation than developing WERs for plume-influenced waters. Consequently, few specific requirements for study design are provided in the USEPA (1994) Interim Guidance; instead, qualitative descriptions and recommendations are provided to guide the investigator in developing the specifics of the study. Since relatively little guidance is provided for WER studies in marine waters, a technical advisory committee (TAC) has been established to provide scientific review and guidance for the SSO study.

The approach used to develop the MdR Harbor WER study design was to adhere to the conceptual approach described in the USEPA (1994) Interim Guidance and implement this approach by using methods shown to be effective in recent California WER studies. Study design and method selection is primarily based on two studies: 1) San Francisco Bay copper and nickel SSO derivation (Clean Estuary Partnership 2005); and 2) studies of copper bioavailability and toxicity in San Diego Bay (Bosse et al. 2014). The San Francisco Bay study resulted in SSOs for copper that were adopted by the regulatory authority for use in total maximum daily loads.

The key elements and sequence of the study design development are shown in Figure 1 and are described in subsequent subsections. Toxicity testing will be the primary method used to calculate WERs. Thus, selecting test species and the test method is the first step in study design (Section 2.1).

The USEPA (1994) Interim Guidance emphasizes the importance of developing a sampling design that takes into account variations in water quality likely to affect the WER. Potential sources of variability include seasonality (e.g., summer vs. winter), stormwater discharge, hydrology (tides or depth), and episodic events (e.g., plankton blooms and harbor activities). The relative importance of these factors in controlling or influencing bioavailability of copper in MdR Harbor is not well-known. A site characterization study was conducted in 2018 to document the water quality characteristics and toxicity in MdR Harbor. The results of the characterization study and critical condition determination (described in Appendix C) were used to develop the final WER study design (Section 2.2). The study design emphasizes sample collection during the conditions when the WER is expected to be lowest and the risk of copper toxicity is greatest, known as the critical condition. Each water sample will be analyzed to determine the copper toxicity EC50, copper concentration, and BLM parameters.

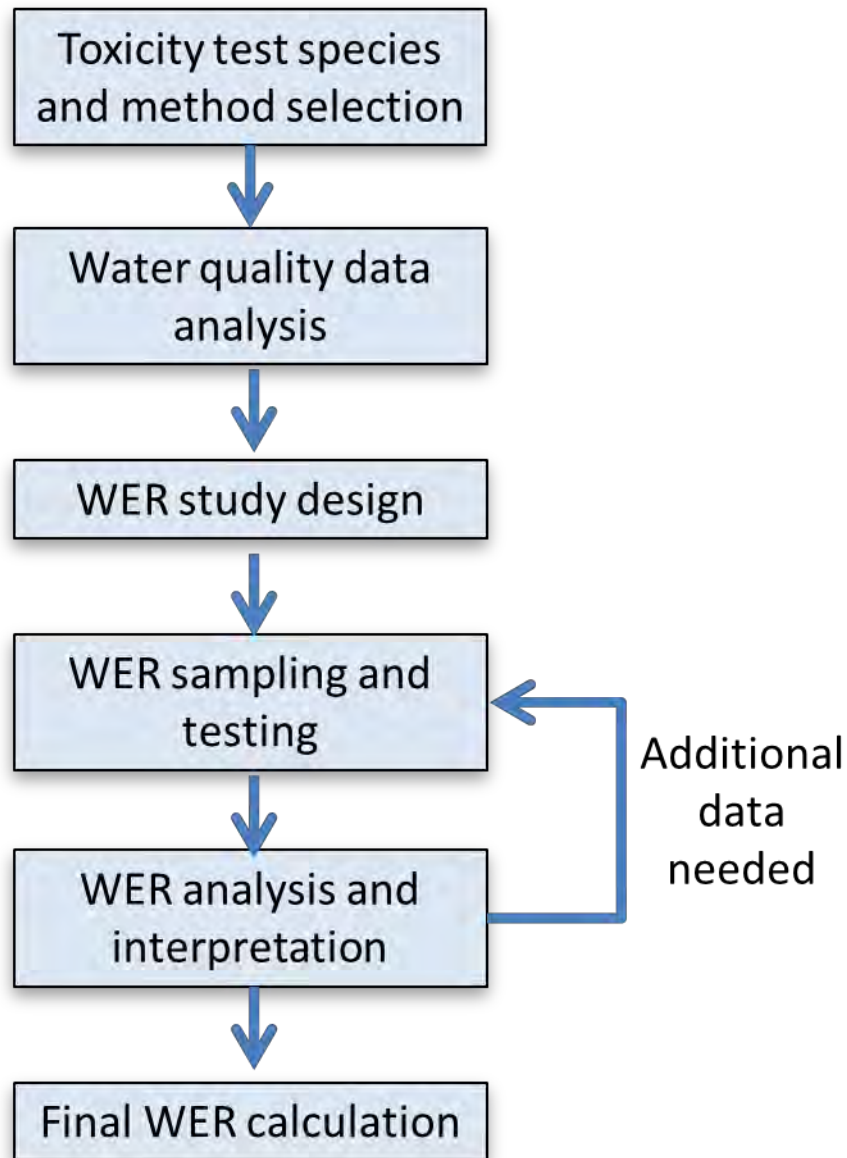


Figure 1. Study elements and process.

Methods for determining the copper EC50 for each sample are described in Section 2.3. The chemistry and toxicity data will be reviewed and used to calculate the sWER for each sample (Section 2.4). This step will include an assessment to determine if sWER data are sufficient to support the objectives of the study. If deficiencies are present, additional sampling may be needed to resolve them. The final step in the data analysis is the calculation of the final WER (fWER, Section 2.5).

2.1 Toxicity Test Species and Method Selection

Toxicity tests will be conducted using embryos of the *M. galloprovincialis*. This species is recommended for WER calculation in the USEPA (1994) Interim Guidance and has been the primary or sole species used for WER development in recent studies in San Francisco Bay (San Francisco Bay RWQCB 2007a) and San Diego Bay (Bosse et al. 2014). *M. galloprovincialis* is an ideal organism for use in WER copper studies because of its sensitivity to copper and commercial importance. When deriving a site-specific criterion, it is desirable to use a test species whose sensitivity is near the Final Acute Value (FAV). Mussels, *Mytilus sp.* (multiple species), is the most sensitive marine species listed by EPA, with a species mean acute value (SMAV) = 6.19 µg/L. The current EPA saltwater criteria for copper are based on this value to protect this commercially important species. The sensitivity of *M. galloprovincialis* embryo development to copper is similar to that of *Mytilus sp.* The average EC50 for *M. galloprovincialis* from the three Site Characterization study events was 8.12 µg/L (Appendix C). Use of *M. galloprovincialis* helps provide a margin of safety for SSO development for two reasons:

- The current CTR criterion for copper is determined exclusively by *Mytilus sp.*, a grouping that includes *M. galloprovincialis*, for protection of this commercially important species group. Using this species in the MdR Harbor SSO study will help ensure that the same level of protection is maintained.
- Mussels, including *M. galloprovincialis*, represent the most sensitive genus in the national saltwater copper toxicity database. They are not only a good surrogate for invertebrate species in general (which tend to be more sensitive to copper than vertebrates) and mollusks (a phylum sensitive to copper; the third, fourth, and sixth most sensitive species in the national copper database are mollusks), but also it is a good surrogate for other sensitive saltwater aquatic animals.

The TAC agrees that *M. galloprovincialis* is both appropriate and sufficient for the WER toxicity tests and that no additional organisms need to be tested. (Appendix E). However, if this organism proves too difficult to spawn, other sensitive test species could be considered. These include *Mytilus californianus* (California mussel) and *Crassostrea gigas* (Pacific oyster). Both of these organisms are also found in MdR Harbor and are similarly sensitive.

2.1.1 Test Method

Site water and laboratory control seawater toxicity will be measured using a 48-hour exposure of mussel embryos under standard conditions as described USEPA (1995). Test conditions are summarized in Table 1 and detailed methods are described in Appendix A. Control seawater will be obtained from a reference site in Granite Canyon, California, and filtered (0.45 micron) prior to use to remove resident organisms and particulate organic material. This reference site has been used for control water in previous WER studies in San Francisco Bay and San Diego Bay due to its previously reported acceptability for embryo-larval development tests and relatively low DOC content. Toxicity tests will be initiated within 36 hours of sample collection. Each sample/treatment will be tested using five replicates. For each replicate, approximately 250 *M. galloprovincialis* embryos will be exposed in 10 milliliters (mL) of sample for 48 hours. Samples of each treatment will be collected for chemical analysis at the beginning (total and dissolved copper; DOC) and end (dissolved copper) of the exposure period to provide a measured EC50 value.

Embryos are preserved for examination at the end of the exposure period. The preserved samples are examined using a microscope to determine the numbers of normal and abnormal surviving embryos (Figure 2). The percent of normal embryos is calculated from the count. Levels of key water quality parameters (dissolved oxygen, pH, salinity, and temperature) and control performance will be evaluated to assess test batch acceptability and organism condition. The salinity range has been adjusted from 30 ± 2 g/kg (USEPA guidance) to 32 ± 2 g/kg to reflect the local environmental conditions and reduce the need to dilute the site water to adjust salinity, which would alter the DOC and copper concentrations. The test will be considered acceptable if three criteria are met: 1) mean normal development in the controls must be at least 90%; 2) mean survival in the controls must be greater than 50%; and 3) the percent minimum significant difference must be less than 25%. The results of copper reference toxicant tests will be compared to past results in order to evaluate sensitivity of test organisms (EC50 should be within two standard deviations of laboratory mean). Standard statistical methods will be used to calculate the copper EC50 (concentration causing 50% reduction in percent normal-alive) for each sample type. EC50 will be expressed in terms of measured dissolved copper concentration.



Figure 2. Normally developed (left) and abnormal mussel embryos
(images courtesy of Sanitation Districts of Los Angeles County)

Table 1. Summary of test conditions for 48-hour mussel embryo development test

Test Species	<i>Mytilus galloprovincialis</i>
Test Procedures	USEPA/600/R-95/136
Age/Size Class	Embryo
Endpoint	Normality of development and survival
Test Type/Duration	Acute static non-renewal/48 hours
Sample Storage Conditions	4°C, dark, minimal head space
Holding Time	≤ 36 hours
Control	Filtered natural seawater (from Granite Canyon, California)
Salinity Adjustment	Hypersaline brine
Water Quality Parameters	Temperature 15 ± 1°C; Dissolved oxygen ≥ 4.0 mg/L
	Salinity 32 ± 2 g/kg; pH 7.5 to 8.3
Photoperiod	16 hours light, 8 hours dark
Test Chamber	22 mL glass shell vials
Replicates/Sample	5
No. of Organisms/Replicate	250
Exposure Volume	10 ml
Aeration/water renewal	None
Feeding	None
Reference Toxicant	Copper chloride
Test Acceptability Criteria	Control mean normal development ¹ ≥ 90%
	Control mean survival > 50%
	Percent minimum significant difference < 25%

Notes:

g/kg = grams per kilogram; mg/L = milligrams per liter; mL = milliliters

USEPA = U.S. Environmental Protection Agency

¹ *Applied to surviving control embryos*

2.2 Water-Effect Ratio Study Design

The study design is based on the conceptual approach outlined in the USEPA (1994) Interim Guidance and includes key design elements used in three recent WER studies conducted in California. The USEPA (1994) Interim Guidance recommends that WER analyses be conducted over a range of conditions so that the results are representative of the variations in water quality at the site. The guidance also states that the study should include multiple stations distributed over a minimum of three separate sampling events that include different seasons and locations.

The USEPA (1994) Interim Guidance recommendations have been implemented in different ways in recent California studies. For the Los Angeles River and tributaries total maximum daily load WER study, a preliminary study design was developed that included six sampling events that were distributed among three seasonal conditions: summer dry weather, winter dry weather, and winter wet weather (Steering Committee 2014). This sampling design was informed by prior studies using the BLM and refined on the basis of initial study results. The WER study for San Francisco Bay (north of Dumbarton Bridge) used a study design that was modeled after ongoing regional water quality monitoring programs (Clean Estuary Partnership 2005). Station locations were selected to match those used in other monitoring programs and represent variations in water depth and harbor region. Two sampling events were conducted in each of two seasons: wet and dry. WER analyses conducted in Shelter Island Yacht Basin were based on only two season-specific sampling events: the summer dry season and the winter wet season following a major storm event (Bosse et al. 2014). This study also examined spatial variation by distributing stations along a transect from the head to the mouth of the basin and investigated variation related to depth by collecting samples near the surface and just above the bottom at each station. Among these studies, the size, morphology, and hydrology of the Shelter Island Yacht Basin study site is the most similar to that of MdR Harbor.

2.2.1 Station Locations

The station locations for the study are a subset of 11 candidate stations used in previous monitoring surveys (Figure 3, Table 2). These stations include nine locations used for metals analysis in the MdR Harbor TMDL Coordinated Integrated Monitoring Program (CIMP; Weston 2014), consisting of one station in each of the harbor's eight basins (MdRH-A through H) and one station at the end of the main channel (MC1). These stations were augmented by adding two additional main channel stations, located near the harbor entrance and near the mid-point of the channel. Some of these stations are located near the major stormwater outfalls into the Harbor (Figure 4). All 11 stations were sampled in 2018 in a site characterization study to document variations in harbor water quality associated with factors such as urban runoff, boat density, water circulation, and shipyard activities. Co-location of the stations with the CIMP will increase the comparability of data between the two programs.

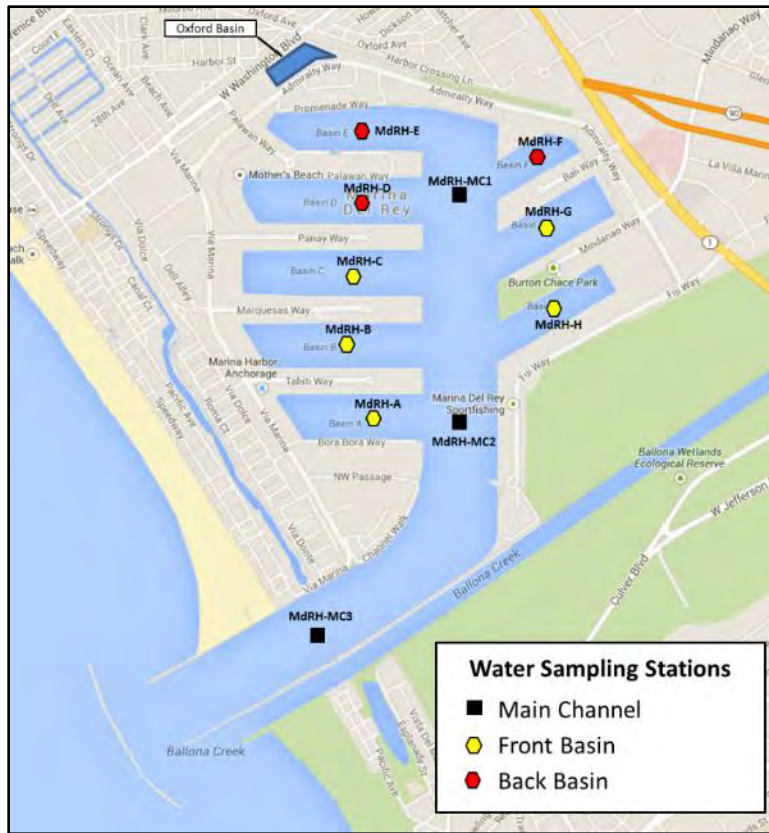


Figure 3. Site characterization sampling stations in Marina del Rey Harbor.

Table 2. Station locations

Station ID	Description	Latitude	Longitude
MdRH-MC1	Main Channel, end	33.98054	-118.44819
MdRH-MC2	Main Channel, middle	33.97231	-118.448
MdRH-MC3	Main Channel, entrance	33.96427	-118.455
MdRH-A	Front Basin A, middle	33.97251	-118.45284
MdRH-B	Front Basin B, middle	33.97514	-118.45346
MdRH-C	Front Basin C, middle	33.97773	-118.45372
MdRH-D	Back Basin D, middle	33.98022	-118.45356
MdRH-E	Back Basin E, middle	33.98301	-118.45338
MdRH-F	Back Basin F, middle	33.98198	-118.44502
MdRH-G	Front Basin G, middle	33.97939	-118.44435
MdRH-H	Front Basin H, middle	33.97635	-118.44409



Figure 4. Storm drain and outfall locations (adapted from Figure 1-1 in the Marina del Rey Coordinated Integrated Monitoring Program document, February 29, 2016).

In addition to the outfalls indicated on the map, stormwater enters the MdRH main channel from Ballona Creek and the Grand Canal.

2.2.2 Site Characterization

Three water quality surveys were conducted in 2018 to characterize variations in Harbor water quality for parameters affecting copper toxicity (Table 3). One event occurred in March, the day after a rain event resulting in 1.1 inches of precipitation. The other two events (May and September) represented dry weather conditions in the Harbor. Water samples were collected from the surface and near bottom during the first two events, and from the surface only during the third event. Each sample was analyzed for parameters required to apply the BLM (pH, salinity, temperature, DOC), as well as total and dissolved copper, chlorophyll, and toxicity (mussel embryo development test).

Table 3. Water quality survey events.

Event	Date	Description	Precipitation (in)	Depth ¹
1	3/23/2018	Winter, wet weather	1.1	S, B
2	5/21/2018	Spring, dry weather	0	S, B
3	9/10/2018	Summer, dry weather	0	S

¹ S = Surface; B = Bottom

Seasonal and spatial variations in DOC were observed among the sampling events (Table 4). Seasonally, DOC was highest on average and more variable during event 1 (wet weather), compared to the two dry weather events. Discharge of stormwater runoff containing high concentrations of organic material to harbor surface water is the likely cause of this pattern. This hypothesis is supported by generally lower DOC concentrations in event 1 bottom water samples, compared to surface samples. Little difference in surface and bottom DOC concentrations were observed during dry weather (event 2).

A spatial pattern in DOC concentration was apparent for each sampling event. The lowest DOC concentrations were always observed at stations in the front basins (A) or in the main channel, close to the harbor mouth (MC3). Locations of the highest DOC were more variable but were frequently located in the back basins of the Harbor. This spatial pattern is likely related to circulation patterns within the Harbor, with sites having greatest mixing with relatively low DOC offshore water (front basins, main channel) having lower DOC concentrations.

Chlorophyll content of the water also varied spatially, with higher concentrations usually present in the back basins. Increases in Chlorophyll (a measure of biological productivity) was also correlated with elevated DOC.

Table 4. Water quality survey results for dissolved organic carbon.

Event	Description	Depth	DOC (mg/L)		
			Average	Lowest	Highest
1	Winter, wet weather	S	1.1	0.88 (MC3)	1.41 (A)
1	Winter, wet weather	B	0.94	0.78(MC3)	1.12 (H)
2	Spring, dry weather	S	0.77	0.54 (A)	1.0 (D)
2	Spring, dry weather	B	0.76	0.44 (MC3)	0.95 (MC1)
3	Summer, dry weather	S	0.84	0.74 (MC3)	1.02 (H)

The water quality results indicate that the critical condition, when water quality characteristics provide the greatest relative copper bioavailability, is likely to occur in winter or spring dry weather, when lower DOC concentrations are present.

Based on the 2018 water quality results, a subset of five stations is recommended for WER analysis (Figure 5), with composite samples being collected from three locations in each of the four selected basins (see 2.2.3 Sampling Design). These stations represent locations where DOC concentrations are likely to be lowest (main channel station 3, front basins A and B), as well as locations where DOC and copper concentration are likely to be high (back basins E and F). Additionally, these locations encompass many of the major stormwater outfalls in the Harbor (Figure 4) and should provide representative results during wet weather sampling. Sampling these stations at multiple times throughout the year is expected to represent variations in water quality factors controlling copper bioavailability throughout the Harbor, as well as encompassing the critical condition during each sampling event. The complete report detailing site characterization and critical condition determination is included in Appendix C.

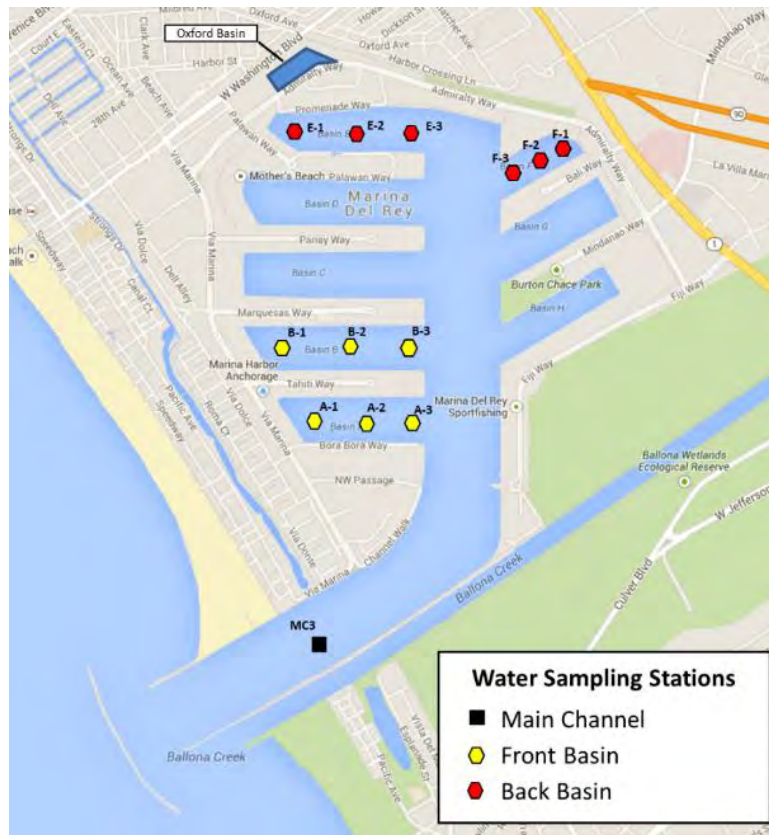


Figure 5. Proposed stations for WER analysis.

2.2.3 Sampling Design

Six sampling events are proposed for WER calculation (Table 5). The events will be distributed over an approximately 12-month period to capture major seasonal variations in water quality. Most of the sampling events (4, or 5 events) will occur during dry weather, when the critical condition is expected to be present. The specific time of the sampling will be determined by seasonal conditions. The sampling plan incorporates the three environmental factors expected to have the greatest influence on copper bioavailability: harbor location (e.g., mixing with coastal water), season, and stormwater discharge. The actual number of sampling events conducted may vary, depending on the results of the first five events. The variability in WER values for the first five sampling events will be reviewed, in consultation with the TAC, to determine the need for additional sampling events. All samples will be collected at 1 m below the water surface. In addition to the WER sample events, LACPW will collect and analyze DOC samples from the main channel and selected basins during their monthly TMDL monitoring program (CIMP) for one year. Analysis of the CIMP DOC samples began in April 2019 and these data will be included in the final report.

To ensure spatial representativeness, the samples collected from the four basin locations will be composites of the end, middle, and mouth of the basin (Figure 5). For

example, three samples will be collected and pooled together from MdRH-A (e.g., A-1:end, A-2:middle, and A-3:mouth).

The timing of each sampling event will be selected to represent potential temporal variations in water quality associated with stormwater runoff and tides. Sampling will be conducted during both wet and dry weather events. For an event to be considered “wet”, there must have been at least 0.5 inches of rain in the preceding 24 hours and the samples must be taken within 24 hours from the end of the storm. Effects of tidal variation will be documented by conducting dry weather sampling during both spring tides (high variation between low and high tide) and neap tides (low difference between low and high tide). During dry weather, each of the five locations will be sampled twice in one day: once during flood tide and once during ebb tide. These two samples will be composited together such that one final sample per station is collected for chemical and toxicity analysis. The compositing over space and time during each sampling event is intended to increase the representativeness of the data for describing conditions in the Harbor.

Table 5. Proposed water-effect ratio sampling event matrix.

Event	Tide Type		Summer	Winter	
			Dry Weather	Dry Weather	Wet Weather
	Spring	Neap	April – October	November – March	November – March
1	X		X		
2	X			X	
3		X	X		
4		X		X	
5	NA	NA			X
6*	TBD	TBD	TBD	TBD	TBD

Notes:

Wet weather sampling is not dependent on tide type. Sampling event characteristics to be determined based on results of previous events.

NA = not applicable

TBD = to be determined

**The details of Event 6 will be based on review of data from the prior events and discussion with stakeholders and the TAC.*

The tide type and tidal cycle at the time of sampling may affect the degree of mixing of harbor water with offshore coastal water, and thus water characteristics such as dissolved organic carbon concentration. Previous studies in bays have shown that the WER is strongly influenced by the water circulation and degree of mixing with coastal

water (Tetra Tech et al. 2000). Variations in both tidal stage and relative change in tide level will be considered in planning the sampling events.

Seasonal dry weather sampling is consistent with the design used in previous WER studies. Variations in temperature, plankton abundance, DOC production, and runoff inputs are expected to be associated with these seasons. Two sampling events are planned for each season, with each event representing a different phase of the tidal cycle.

One sampling event during wet weather (following substantial rainfall, ≥ 0.5 in) is proposed to confirm preliminary findings that indicate relatively low copper bioavailability during this time. The magnitude of the influence of stormwater discharges on copper bioavailability in MdR Harbor is likely to be variable. Depending on the amount of local precipitation and tides, stormwater enters the harbor via discharge from the Oxford Flood Control Basin to Basin E, from a portion of the Ballona Creek discharge plume that is reflected into the main channel by the breakwater, from the Grand Canal, and from multiple storm drains throughout the harbor complex (Figure 4). The impact of stormwater discharge on the WER should be captured by the chosen station locations. In Shelter Island Yacht Basin, lower WERs were obtained for the wet weather sampling event (Bosse et al. 2014). For MdR Harbor, at least one sampling event will be conducted shortly after a qualifying rain event to evaluate the influence of wet weather conditions on the WER and ambient toxicity. Qualifying criteria for sampling will include local precipitation of at least 0.5 inch and an antecedent dry period of at least 3 days.

2.2.4 Parameters to be Analyzed

Several water quality parameters (e.g., pH, temperature, dissolved oxygen, and salinity) will be measured using probes in the field at the time of water sampling (Table 6). Grab samples of water will be collected 1 m below the water surface at each station for measurement of DOC, metals, and toxicity. Concentrations of both copper and zinc will be measured, as both metals may be elevated in harbors and contribute to ambient toxicity. Zinc concentrations in MdR Harbor are not expected to exceed water quality standards but may be a partial contributor to variations in Harbor water toxicity. Inclusion of zinc in this study will facilitate a greater capability to interpret ambient toxicity test results.

In addition to the quantitative analysis of DOC, a subsample (5-10 mL) of the filtrate will be taken prior to sample acidification for qualitative analysis. Spectrophotometric characterization of the subsample will be performed to determine the specific absorbance coefficient at 340nm (SAC_{340}), which is an indicator of DOC aromaticity (Tait et al. 2016). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color.

$$SAC_{340} = 2303 (Abs_{340}/DOC)$$

Where Abs₃₄₀ is the sample absorbance at 340 nm and DOC is the concentration in mg/L.

Table 6. Analytes for WER study

Analyte	Occasion of Measurement		Analysis Method	Use
	Field	Laboratory		
pH	X		Probe	BLM
Temperature	X		Probe	BLM
Salinity	X		Probe	BLM
Dissolved Oxygen	X		Probe	Water quality
Dissolved Organic Carbon ¹		X	Instrument	BLM
Total Copper		X	ICP/MS	Water quality
Dissolved Copper		X	ICP/MS	Water quality
Total Zinc		X	ICP/MS	Water quality
Dissolved Zinc		X	ICP/MS	Water quality
Toxicity		X	Laboratory Test	Ambient toxicity

Notes:

BLM = Biotic Ligand Model

¹ DOC characterization by spectrophotometry will be conducted on selected samples.

2.2.5 Sample Collection and Processing

Methods for water sample collection and processing are described in Appendix A. Briefly, a peristaltic pump fitted with Teflon-lined tubing will be used to collect water samples and fill plastic bottles specific for each analyte type (Table 7). Samples for measurement of DOC and dissolved metals will be filtered in the field within 15 minutes of collection using plastic syringes fitted with 0.45-micron filters. A “clean hands/dirty hands” technique will be employed during sampling and filtering to prevent contamination of the samples. All samples will be placed in coolers with wet ice for temporary storage. Sampling equipment will be pre-cleaned prior to the sampling event. The pump system will be flushed with site water prior to use at each station. A new filter apparatus will be used for each station.

Table 7. Volumes and containers for field samples.

Analysis Type	Volume (mL)	Container Type/Size
Dissolved organic carbon	40	Pre-combusted glass vial
Dissolved metals	50	Polypropylene tube
Total metals	50	Polypropylene tube
Toxicity	1,000	HDPE bottle

Note:

mL = milliliters

2.2.6 Documentation of Chain-of-custody

Samples are considered to be in one's custody if they are in the custodian's possession or view or retained in a secured place. The documents used to identify samples and to document possession include the chain-of-custody (COC) records and the field form. COC procedures will be used for all samples throughout the collection and analytical process. COC procedures will be initiated during sample collection. A COC record will be provided with each sample group. Each person who has custody of the samples will sign the form to ensure that the samples are not left unattended. COC forms will be signed by the person transferring samples custody. Additional information regarding COC and a copy of the COC form can be found in the Quality Assurance Project Plan (QAPP; Appendix A).

2.2.7 Analysis Methods

The methods for chemical analysis of the samples are described in the Appendix A. The methods have been selected to provide reporting limits below the levels expected in MdR Harbor (Table 8). Metal analysis will be conducted according to USEPA Method 1640 for trace elements in water, using inductively coupled plasma mass spectrometry. In this procedure, trace elements are pre-concentrated based on their reductive precipitation by sodium tetrahydroborate; iron and palladium are added to samples to aid co-precipitation of metal borides and to enhance the precipitation of metals coming out in the elemental form.

Table 8. Chemistry and toxicity analysis methods and reporting limits.

Analyte	Method Detection Limit (µg/L)		Reporting Limit (µg/L)		Analysis Method
	Total	Dissolved	Total	Dissolved	
Organic Carbon	NA	55	NA	55	EPA 9060a
Copper	0.025	0.005	0.025	0.15	USEPA 1640 – FePd
Zinc	0.025	0.025	0.025	0.15	USEPA 1640 – FePd
Toxicity	NA	NA	NA	NA	USEPA 1995

*Notes:**µg/L = micrograms per Liter**NA = not applicable**SM = Standard Method**USEPA = U.S. Environmental Protection Agency*

Dissolved organic carbon will be analyzed using EPA Method 9060a for the analysis of total organic carbon by combustion or oxidation. With this method organic carbon in a sample will be converted to carbon dioxide by catalytic combustion or wet chemical oxidation. The carbon dioxide formed can be measured directly by an infrared detector or converted to methane and measured by a flame ionization detector. The amount of carbon dioxide or methane is directly proportional to the concentration of carbonaceous material in the sample.

Ambient toxicity in the water samples will be measured using the 48-hour mussel embryo development test (Section 2.1). The toxicity test results from the unmodified samples from each dose-response test (no added copper spike) will provide insight to the level of ambient toxicity in MdR Harbor. MdR Harbor sample toxicity will be compared to the laboratory control (filtered seawater from reference site).

2.2.8 Biotic Ligand Model Analyses

The BLM is a chemical speciation model that can be used to predict the adverse effect levels of metals as a function of water chemistry. A freshwater version of the BLM for copper has been developed and approved by the USEPA for use in developing site-specific water quality criteria (Santore et al., 2001). For this study, the marine BLM for copper in saltwater developed by Robert Santore (Version 3.16.2.41 from Windward Environmental, LLC), which is currently under review for use by the USEPA in setting water quality criteria, will be used. Previous research provides a more in-depth description of the model parameters and equations, and its applications to both freshwater and marine systems (Di Toro et al. 2001; Santore et al. 2001; Arnold et al. 2005; Chadwick et al. 2008).

Application of the BLM requires the input of four water chemistry parameters from the site: salinity, temperature, pH, and DOC. Using chemical speciation data of the different components in seawater, the BLM will be used to predict the $EC_{50_{BLM}}$; the concentration of dissolved copper needed to produce an adverse effect on 50% of developing mussel embryos in samples of both site water and laboratory control seawater. The predicted EC_{50} values will be used to calculate the BLM predicted WER, defined as the site water $EC_{50_{BLM}}$ divided by the control water $EC_{50_{BLM}}$ (see Equation 3 in Section 1.2.2).

2.2.9 Sampling Quality Assurance/Quality Control

Multiple quality assurance (QA) samples will be collected and processed in the field. QA samples include travel blanks, field blanks, field duplicates, and matrix spikes (Table 9). One of each QA sample type will be collected during each sampling event. Furthermore, samples of tubes, syringes, filters, and bottles from every new manufacturing lot will be sent to the analytical laboratory for blank analysis.

Table 9. Description of quality assurance sample types for field sampling.

Sample Type	DOC Volume (mL)	Total Metals (mL)	Dissolved Metals (mL)
Travel Blank	40	50	50
Field Blank	40	50	50
Field Duplicate	40	50	50
Matrix Spike Blank	na	50	50
Pump Tubing Blank	40	50	50

Notes:

DOC = dissolved organic carbon

mL = milliliters

2.3 Dose-Response Testing

All water samples will be tested for toxicity and WER calculation using test methods described in Section 2.1. A series of spiked copper treatments will be prepared and tested for EC_{50} determination. The spiking methods will follow recommendations in the USEPA (1994) Interim Guidance. Water from each MdR Harbor station and the laboratory control will be spiked to generate a series of copper concentrations designed to produce toxicity results ranging from no effect to complete inhibition of normal embryo development (assuming minimal ambient toxicity). Results from samples with ambient toxicity will be reviewed in consultation with the TAC to determine if a valid EC_{50} can be calculated for that sample.

Copper-spiked water samples for WER tests will be prepared by adding reagent grade copper salt solutions. Spiking methods and concentrations will be consistent with the

USEPA (1994) Interim Guidance. Spikes will be equilibrated for 12-24 hours before testing. Both site water and control water samples will be spiked with specific amounts of copper to produce six to nine treatments that range from a dose that does not cause toxicity to a dose that causes nearly complete mortality or abnormal development. Data from preliminary tests will be used to select treatment concentrations for MdR Harbor water. Spiked control water treatments are expected to range from approximately 2 to 30 µg/L.

Toxicity test results for each copper treatment will be expressed as average percentage normal of five replicate test chambers. Control performance will be compared to test acceptability criteria and water quality specifications (Table 1) to verify data quality. The spiked copper treatments for every sample will be analyzed to verify dissolved copper concentrations. Only those treatments used in the statistical analysis to determine the EC50 will be submitted for chemical analysis.

2.4 Water-Effect Ratio Analysis and Interpretation

The USEPA (1994) Interim Guidance on calculating and interpreting results will be followed in this study. The general steps include:

- Evaluating the acceptability of each toxicity test
- Calculating the results of each test
- Evaluating the acceptability of the laboratory dilution water
- Calculating the sWERs
- Investigating the WER

Completing the first three steps and calculating copper EC50 values for each sample will use methods and criteria in accordance with USEPA (1995). Generally, the EC50 will be determined using the Trimmed Spearman-Kärber method.

The sWER will be calculated as the ratio of the sample EC50 divided by the control EC50 (Section 1.2.1). The BLM predicted sWER will also be calculated for each sample for comparison purposes only. The predicted sWER is calculated using copper EC50s for the sample and laboratory control predicted by the BLM.

2.4.1 Toxicity Quality Assurance/Quality Control

The practices used by the toxicity laboratory to ensure reliable, high-quality results for the tests conducted for this project are described in the QAPP (Appendix A). The objectives for accuracy and precision involve all aspects of the testing process, including:

- Seawater sampling and handling
- Source and condition of test organisms
- Test conditions

- Instrument calibration
- Use of reference toxicants
- Record keeping
- Data evaluation

Concurrent reference toxicant tests will be conducted for each toxicity test batch to verify the sensitivity and health of the test organisms. The reference toxicant EC50 will be compared to a control chart of historical values. Water quality parameters will be monitored to ensure that they fall within prescribed limits; corrective action will be taken if necessary. All limits established for this study meet or exceed those recommended by the USEPA. All data collected or produced from these analyses will be recorded and summarized to become part of the permanent data record for this study.

In addition, samples from one laboratory water reference toxicant series will be split and analyzed by a second toxicity testing laboratory. This will provide an interlaboratory comparison of the toxicity test results to provide further quality assurance.

2.4.2 Chemistry Quality Assurance/Quality Control

- Detailed descriptions of QA/quality control (QC) procedures and data quality objectives (DQOs) for the chemical analyses of samples for this project are contained in the QAPP (Appendix A) and chemistry laboratory standard operation procedures included with the QAPP. QA/QC involves all testing aspects, including:
 - Method SOPs
 - Calibration methods and frequency
 - Data analysis, validation, and reporting
 - Internal QC
 - Preventive maintenance
 - Procedures to ensure data accuracy and completeness

Laboratory QC results, qualifications, and exceptions will be reported. Laboratory accuracy will be indicated by analysis of matrix spikes, blank spikes, certified reference materials, and/or recovery surrogates. Certified reference materials will be used during analysis of DOC and dissolved metals concentrations. Matrix spikes will be used to assess the effects that the sample matrix (e.g., seawater) has on the accuracy of a measurement. Blank spikes will demonstrate the performance of the preparation method on a clean matrix, void of potential interferences. Precision will be determined by analysis of duplicate matrix spikes, blank spikes, recovery surrogate spikes, and duplicate test samples. Potential laboratory contamination introduced during analysis will be assessed by analyzing procedural/method blanks. Any QC samples that fail to meet the QC criteria detailed in QAPP (Appendix A) will be identified, corrective action

taken, and the corresponding data will be appropriately qualified in the final report. All QA/QC records will be kept on file.

2.4.3 Water-Effect Ratio Investigation

The sWERs for different stations and events will be summarized and evaluated to determine if the results are sufficient for calculation of the fWER. These analyses will be structured to answer the following questions:

- Do the samples represent typical MdR Harbor conditions?
- Is the critical condition adequately represented?
- Is the sWER sample size and precision sufficient for calculation of the fWER?
- Are the toxicity-based and BLM predicted sWERs comparable?

Water quality (e.g., pH, DOC, temperature, and salinity) and copper concentration measurements for the field samples will be compared to values obtained in the site characterization study and TMDL monitoring to determine if the samples are representative of MdR Harbor. Statistical evaluation will include comparing sample data to the 95% confidence interval for the parameters.

Representation of the critical condition will be assessed by comparing the season and tide stage of each sampling event to the conditions used to define the critical condition. A determination will be made as to whether the goal of conducting four sampling events during the critical condition was met.

The criteria and statistical methods used to evaluate sWER sample size precision will be developed in consultation with the TAC and stakeholders during the data review process. In addition to the recommendation from the TAC, the coefficient of variation and 95% confidence intervals will be calculated for the sWER dataset (or region-specific subset) and compared to the maximum interval size desired.

Three approaches will be used to investigate the comparability of the toxicity-based and BLM predicted sWERs:

1. Summary statistics (e.g., mean, standard deviation, and range) will be compared between the two types of sWER. This analysis will indicate the overall magnitude of differences between the methods.
2. T-tests or ANOVA will be used to determine if mean sWERs are significantly different.
3. Graphical methods (e.g., scatterplots) will be used to compare pairs of individual sWERs matched by station. This analysis will indicate whether there is a pattern of consistent bias between the two WER approaches.

The results of the WER investigations described above will be reviewed to determine if data are sufficient to support fWER calculation at the desired level of precision and seasonal specificity. A minimum of three sampling events is recommended by the USEPA (1994) Interim Guidance, which is half the number of events proposed in this work plan. Additional data from the 2018 site characterization analyses will be included in the evaluation. If the data are not sufficient, the feasibility of conducting additional sampling and analyses will be explored.

2.5 Final Water-Effect Ratio Calculation

The fWER will be calculated as the geometric mean of the group of sWERS selected for analysis, as recommended in the USEPA (1994) Interim Guidance. The geometric mean is calculated as the average of the natural log-transformed sWERS. The number and type of fWERs calculated will depend on the characteristics of the sWERS and final study objectives. For example, if statistical analyses indicate that sWERS collected in different regions of the harbor (or different seasons) are similar, then data may be pooled and a single fWER calculated. Alternatively, several fWERs may be calculated to represent important variations in critical condition or copper bioavailability (e.g., front basins vs. back basins). Similarly, if the sWERS are highly variable, use of the lowest sWER may be considered. A determination of the number and type of fWERs to be calculated will be made in consultation with the TAC and local stakeholders.

3 DATA MANAGEMENT

Data management will involve compiling data collected as part of the SSO study into standardized formats, data review, and export of field, toxicity test, and chemistry data as flat files that are accessible by Los Angeles County Public Works (LACPW). Data will be reviewed for quality and completeness, compiled, and exported in CEDEN format to LACPW. The data will be submitted to CEDEN by LACPW.

3.1 Analytical Chemistry Data Quality Review and Management

Analytical chemistry data will be submitted by the laboratory in specified PDF and electronic data deliverable formats. Analytical data will undergo verification and validation in accordance with the QAPP (Appendix A) and final validation qualifiers will be applied and stored. A concise data validation summary will be prepared and included in the final report.

3.2 Toxicity Test Data Quality Review and Management

All toxicity test data including laboratory bench sheets and randomization sheets (listed in the QAPP; Appendix A) will be reviewed to ensure that data meet QA/QC standards specified in the standard method guidance documents. The toxicity test data review process is detailed in the QAPP and briefly described here. A determination will be made as to whether DQOs were met by assessing test acceptability criteria, reference toxicant test results, protocol deviations (i.e., water quality deviations), sample handling notes, and data completeness. Minor data quality issues, that likely do not affect the test outcome, will be noted and summarized in the final report. Database contents will be compared to bench sheets to ensure that the electronic data are complete and accurate.

3.3 Data deliverables

A draft Excel database containing data collected during the first half of the SSO study will be provided before the end of 2019. A final Excel database containing field sampling coordinates, field water quality measurements, compiled validated analytical data, and compiled toxicity summary data for the entire study will be provided along with the final report.

4 DELIVERABLES AND REPORTING

4.1 Task Reports

Interim progress reports and data summaries will be provided as specific study tasks are completed. The format and content of these reports will vary, according to the nature of the activity. Preliminary data and reports will be made available to stakeholders when they are sent to the TAC for review. Discussion regarding changes to the work plan will occur during the quarterly TAC meetings and will be open to stakeholder participation. Reports for key tasks will include the following:

- Quarterly progress reports covering all activities
- Summary of field sampling events, including station locations and a description of deviations from the sampling plan
- Summary of water chemistry results for each sampling event
- Summary of toxicity results for each testing event
- Summary tables of WER values, BLM output, and predicted WERs
- Data validation summary

4.2 Site-specific Objective Study Report

The results of the SSO tasks will be summarized, integrated, and evaluated in a draft report. The final dataset will be provided to LACPW/Los Angeles County Beaches and Harbors (LACDBH) in CEDEN format. Laboratory reports, copies of field forms, and data validation reports will be included as appendices. At a minimum, the following will be included in the report:

- Summary of all field activities, including a description of any deviations from the approved work plan
- Locations of stations in latitude and longitude (degrees, decimal minutes)
- Project maps with actual sampling locations
- Summary of water chemistry results compared to CTR criteria
- Summary of toxicity results and WER values
- Conclusions
- Data validation summary

A draft study report (one electronic copy) will be prepared for LACPW review and comment. Following receipt of comments and revisions to the draft report, a draft final report will be prepared for review by the TAC, RWQCB, and other stakeholders. All comments will be reviewed and addressed, and a final report will be prepared and provided to LACPW (three hard copies and an electronic copy).

5 PUBLIC PARTICIPATION PLAN

Public participation will be actively sought during the SSO study. Various stakeholders including non-governmental organizations (NGOs), boaters, marina operators, Harbor lessees, and other interested parties will be invited to listen in during all TAC review meetings. In addition, two public information workshops will be conducted. The first TAC review meeting was held in December 2018 after the completion of a draft work plan and concurrent with the public work plan review. TAC and public comments (and responses) on the work plan are included in Appendices E and F.

The first public workshop will be held soon after concurrence from the Regional Board regarding the work plan is obtained. The second workshop will be held after the completion of the draft final report to explain the outcomes of the SSO study and to solicit comments from the public before finalizing the final report. All key documents from the SSO study, including the draft work plan, draft final report, and draft implementation strategy report will be available for public review for a minimum of 30 days once they are submitted to the RWQCB. Public review comments will be considered in preparation of the final documents.

6 TECHNICAL ADVISORY COMMITTEE

A TAC has been established to provide scientific review and guidance for the SSO study. Three scientists with expertise in metal speciation, bioavailability, toxicology, ecology, and water quality modeling comprise the TAC (Table 10). The TAC members were selected based on recommendations from RWQCB staff and environmental groups. Each of the TAC members have international and national recognition as leaders in their field, extensive publication records, and a mixture of local and international experience. The TAC will provide an independent review of the study design, study results, and final report. The TAC will also provide a resource to questions or concerns from stakeholders that require the application of expert judgment. Additional background on the TAC members is provided in Appendix B.

Table 10. Technical Advisory Committee Members

Name	Affiliation	Expertise
Peter Campbell	University of Quebec, INRS, Quebec, Canada	Trace metal analysis, speciation, toxicology, bioaccumulation
Gary Cherr	Bodega Marine Laboratory, University of California, Davis, CA	Reproductive physiology, developmental biology, biochemistry, environmental toxicology
Richard F. Ambrose	University of California, Los Angeles, CA	Assessment, restoration, and remediation of coastal habitats, including wetlands and rocky intertidal. Climate change impact assessment and mitigation.

7 IMPLEMENTATION REPORT

Following the completion of the SSO final report, an implementation report will be developed in coordination with LACPW/LACDBH and the regulatory agency to incorporate the SSO study results in an amendment to the Basin Plan and the Toxics TMDL.

The implementation report will include recalculations of TMDL numeric targets for dissolved copper in MdR Harbor; i.e., chronic CCC will be recalculated using fWERS specific to MdR Harbor. The implementation report will also include recalculation of TMDL load allocation for dissolved copper in MdR Harbor based on the recalculated CCC. In addition, the implementation report will provide analyses to support the implementation of the SSOs for dissolved copper in MdR Harbor including environmental and economic impacts, California Water Code Section 13241, anti-degradation review (as appropriate), and anti-backsliding review (as appropriate).

A draft implementation report (electronic copy) will be submitted to LACPW and the RWQCB staff for review. All comments will be reviewed and addressed accordingly. A final implementation report will be submitted to the LACPW (3 hard copies, 1 electronic copy). A copy of the final implementation report will be also submitted to the RWQCB E.O.

8 PROJECT SCHEDULE

A project schedule with key milestones has been developed and is provided in Table 11.

Table 11. Site-specific objective study schedule

Deliverables	Target Date¹
Review of work plan by stakeholders	November 2018
TAC Meeting 1: Review of work plan ²	December 2018
Submission of revised SSO Work Plan for Los Angeles RWQCB concurrence	March 2019
TAC Meeting 2: conference call to discuss work plan revisions	April 2019
Public Outreach Workshop 1: Study background and description of work plan	July 2019
WER Sampling and Testing	July 2019 to June 2020
TAC Meeting 3: conference call to discuss interim results of WER analyses	October 2019
TAC Meeting 4: conference call to discuss interim results of WER analyses	December 2019
TAC Meeting 5: conference call to discuss preliminary WER results	June 2020
SSO Draft Report and Implementation Draft Report	July 2020
Public Outreach Workshop 2: Presentation of report findings to stakeholders	August 2020
TAC Meeting 6: conference call to discuss TAC's review of the draft report	August 2020
TAC Meeting 7: discussion of revised SSO Final Report	September 2020
Final SSO and Implementation Reports	October 2020

Notes:

RWQCB = Regional Water Quality Control Board

SSO = site-specific objective

TAC = Technical Advisory Committee (all TAC meetings will be open to stakeholder participation)

WER = Water Effect Ratio

1 Dates are for planning purposes only; specific dates for meetings have not yet been established.

2 An orientation conference call with the TAC will be held prior to the December meeting.

9 REFERENCES

- Arnold, W.R., R.C. Santore, and J.S. Cotsifas, 2005. Predicting copper toxicity in estuarine and marine waters using the biotic ligand model. *Marine pollution bulletin*, 50: 1634-1640.
- Bosse, C., G. Rosen, M. Colvin, P. Earley, R. Santore, and I. Rivera-Duarte, 2014. Copper bioavailability and toxicity to *Mytilus galloprovincialis* in Shelter Island Yacht Basin, San Diego, California. *Marine Pollution Bulletin*, 85:1634-1640.
- Chadwick, D.B., I. Rivera-Duarte, G. Rosen, P.F. Wang, R.C. Santore, A.C. Ryan, P.R. Paquin, S.D. Hafner, and W. Choi, 2008. *Demonstration of an Integrated Compliance Model for Predicting Copper Fate and Effects in DoD Harbors*. Environmental Security Technology Certification Program (ESTCP). Project ER-0523. Technical Report 1973. December 2008.
- Clean Estuary Partnership, 2005. *North of Dumbarton Bridge Copper and Nickel Site-Specific Objective (SSO) Derivation*. Prepared by EOA, Inc., and Larry Walker Associates. March 2005.
- Di Toro, D.M., H.E. Allen, H.L. Bergman, J.S. Meyer, P.R. Paquin, and R.C. Santore, 2001. Biotic ligand model of the acute toxicity of metals. Technical basis. *Environmental Toxicology and Chemistry*, 20: 2383-2396.
- DPR, 2009. Monitoring for Indicators of Antifouling Paint Pollution in California Marinas. EH08-05. Environmental Monitoring Branch. California Department of Pesticide Regulation. Sacramento, CA.
- HDR|HydroQual, 2012. Draft Update of Aquatic Life Ambient Saltwater Quality Criteria for Copper. pp. 1–43.
- LWA (Larry Walker Associates), 2006. Calleguas Creek Watershed Copper Water-Effects Ratio (WER) Study. June 8, 2006.
- Los Angeles RWQCB, 2014. State of California Regional Water Quality Control Board, Los Angeles Region. Resolution No. R14-004. *Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise the Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor*. February 6, 2014.
- Los Angeles RWQCB/USEPA (Los Angeles Regional Water Quality Control Board and U.S. Environmental Protection Agency), 2005. *Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor*. October 6, 2005.
- Los Angeles RWQCB/USEPA, 2013. *Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor*. Prepared by Los Angeles RWQCB and U.S. Environmental Protection Agency Region 9. November 5, 2013.

- Rosen, G., I. Rivera Duarte, L. Kear Padilla, and D.B. Chadwick, 2005. Use of laboratory toxicity tests with bivalve and echinoderm embryos to evaluate the bioavailability of copper in San Diego Bay, California, USA. *Environmental Toxicology and Chemistry*, 24: 415-422.
- San Francisco Bay RWQCB (San Francisco Bay Regional Water Quality Control Board), 2002. Resolution R-2002-0061. Amending Water Quality Control Plan for the San Francisco Bay Region to Adopt Site-Specific Objectives for Copper and Nickel in the Lower South San Francisco Bay and an Implementation Plan. May 22, 2002.
- San Francisco Bay RWQCB, 2007a. *Copper Site-Specific Objectives in San Francisco Bay*. Proposed Basin Plan Amendment and Draft Staff Report. June 6, 2007.
- San Francisco Bay RWQCB, 2007b. Resolution R2-2007-0042. To amend the Water Quality Control Plan for the San Francisco Bay Region to Adopt Site-Specific Objectives for Copper for San Francisco Bay and an Implementation Plan. June 13, 2007.
- Santore, R.C., D.M. Di Toro, P.R. Paquin, H.E. Allen, and J.S. Meyer, 2001. Biotic ligand model of the acute toxicity of metals. 2. Application to acute copper toxicity in freshwater fish and Daphnia. *Environmental Toxicology and Chemistry*, 20:2397-2402.
- Steering Committee (Los Angeles River Metals Total Maximum Daily Load Special Studies Steering Committee), 2014. *Final Report, Copper Water-Effect Ratio Study to Support Implementation of the Los Angeles River and Tributaries Metals TMDL*. Prepared by Larry Walker Associates on behalf of the Los Angeles River Metals Total Maximum Daily Load Special Studies Steering Committee.
- SWRCB (State Water Resources Control Board), 2014. Resolution No. 2014-0049. Approving an Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise a Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor. September 9, 2014. Available from: http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/tmdl/tmdl_list.shtml.
- Tait, T.N., Cooper, C.A., McGeer, J.C., Wood, C.M., Smith, D.S., 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.
- Tetra Tech, Inc.; Ross & Associates, Ltd.; and EOA, Inc., 2000. *Task 2 Impairment Assessment Report for Copper and Nickel in Lower South San Francisco Bay*. Sponsored by the City of San Jose. Final Report. June 2000.
- Weston (Weston Solutions, Inc.), 2014. *Marina del Rey Watershed Coordinated Integrated Monitoring Program*. Prepared for Marina del Rey Enhanced Watershed Management Program Agencies. June 28, 2014.

- USEPA (U.S. Environmental Protection Agency), 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. USEPA-823-B-94-001. Office of Water and Office of Science and Technology, Washington, D.C. February 1994.
- USEPA, 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.
- USEPA, 2001. *Streamlined Water-Effect Ratio Procedure for Discharges of Copper*. USEPA/822/R-01/005. Office of Water. Washington, DC.
- USEPA, 2016a. Draft Estuarine/Marine Biotic Ligand Model, EPA Estuarine/Marine Copper Water Quality Criteria Version 0.6.2.39: User's Guide and Reference Manual. Office of Water. Washington, DC.
- USEPA 2016b. Draft Aquatic Life Ambient Estuarine/Marine Water Quality Criteria For Copper – 2016. EPA-822-P-16-001. Office of Water. Washington, DC.

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

Title: SSO QAPP
Revision Number: 3
Revision Date: July 31, 2019

**Quality Assurance Project Plan
for
Marina Del Rey Harbor Site-Specific Objective Study**

Prepared by
Steven Bay and Ashley Parks
Southern California Coastal Water Research Project,
Costa Mesa, CA

Prepared for
Los Angeles County Public Works, Alhambra, CA
and
Los Angeles County Department of Beaches and Harbors, Marina del Rey, CA

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Approvals Signature:

Emiko Innes, Los Angeles County Public Works, Contract Manager

 8/5/19
 Signature Date

Steven Bay, Southern California Coastal Water Research Project, Department Head

 8/13/2019
 Signature Date

Ashley Parks, Southern California Coastal Water Research Project, Scientist

 8/12/19
 Signature Date

Wayne Lao, Southern California Coastal Water Research Project, Chemistry Technician

 8/12/19
 Signature Date

Rich Gossett, Physis Environmental Laboratories, Inc., Contract Analytical Laboratory

 8/9/19
 Signature Date

Renee Spears, California State Water Resources Control Board, Quality Assurance Officer

 08/07/2019
 Signature Date

Shana Rapoport, Los Angeles Regional Water Quality Control Board, Environmental Scientist

 8/15/19
 Signature Date

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
BLM	Biotic Ligand Model
CCC	Criterion Continuous Concentration
CIMP	Coordinated Integrated Monitoring Program
COC	chain-of-custody
CTR	California Toxics Rule
DOC	dissolved organic carbon
DQO	data quality objective
EC50	median effective concentration
fWER	final Water-Effect Ratio
LACDBH	Los Angeles County Department of Beaches and Harbors
LACPW	Los Angeles County Public Works
MdR Harbor	Marina del Rey Harbor
µg/L	microgram per liter
mL	milliliter
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RWQCB	Regional Water Quality Control Board
SSO	site-specific objective
sWER	sample Water-Effect Ratio
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
Toxics TMDL	<i>Reconsideration of the Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor</i>
USEPA	U.S. Environmental Protection Agency
WER	Water-Effect Ratio

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1 PROJECT MANAGEMENT

1.1 Title and Approval Page See pages 1-2.

1.2 Table of Contents See pages 3-5.

1.3 Distribution List

Name	Title	Organization	Email
Steven Bay	Project Manager	SCCWRP	steveb@sccwrp.org
Ashley Parks	Project Lead	SCCWRP	ashleyp@sccwrp.org
Wayne Lao	Chemistry Technician	SCCWRP	waynel@sccwrp.org
Rich Gossett	Contract Analytical Laboratory	Physis Environmental Labs	richgossett@physislabs.com
Emiko Innes	Contract Manager	Los Angeles County Public Works	EINNES@dpw.lacounty.gov
Renee Spears	Quality Assurance Officer	California State Water Resources Control Board	renee.spears@waterboards.ca.gov
Shana Rapoport	Environmental Scientist	Los Angeles Regional Water Quality Control Board	Shana.Rapoport@waterboards.ca.gov

1.4 Project Organization

Contract Manager will have overall responsibility for administering the contract. She will ensure that the project budget and timeline is adhered to. She will communicate with the Project Manager on work accomplished in this plan and any problems or deviations that need to be resolved.

Project Manager will be the responsible official for this project overseeing the overall project and budget, as well as tasking contractors with work required to complete this project. He will communicate project needs to the Contract Manager.

Project Lead will be responsible for coordinating day-to-day project activities, including planning of field sampling activities, toxicity testing, and laboratory analyses. She will also be responsible for data management, quality assurance (QA), and statistical analysis of the data. She will coordinate efforts with the Toxicity Testing Lead, Field Sampling Coordinator, Chemistry Technician and Contract Laboratory Director. She will also communicate project needs to the Project Manager.

Toxicity Testing Lead will be responsible for coordinating laboratory toxicity tests. He will report to the Project Lead.

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Field Sampling Coordinator will be responsible for coordinating field sampling events with the Field Sampling Team Lead and Staff. He will report to the Project Lead.

Field Sampling Team Lead will be responsible for coordinating field sampling events with the Field Sampling Coordinator.

Chemistry Technician will provide chemical analysis of water samples for dissolved organic carbon. He will report data to the Project Lead.

Contract Laboratory Director will coordinate and oversee sample preparation and chemical analysis of water samples for total and dissolved metals. He will report data to the Project Lead.

Regional Board Liaison will be responsible for coordinating Water Board review and approval of the Work Plan and QA Project Plan. She will also provide policy guidance and input on sampling design, analytical methods, and data analysis.

State QA Officer will be responsible for reviewing and approving the QA Project Plan, including providing input on proposed sampling design, analytical methodologies, and data analysis.

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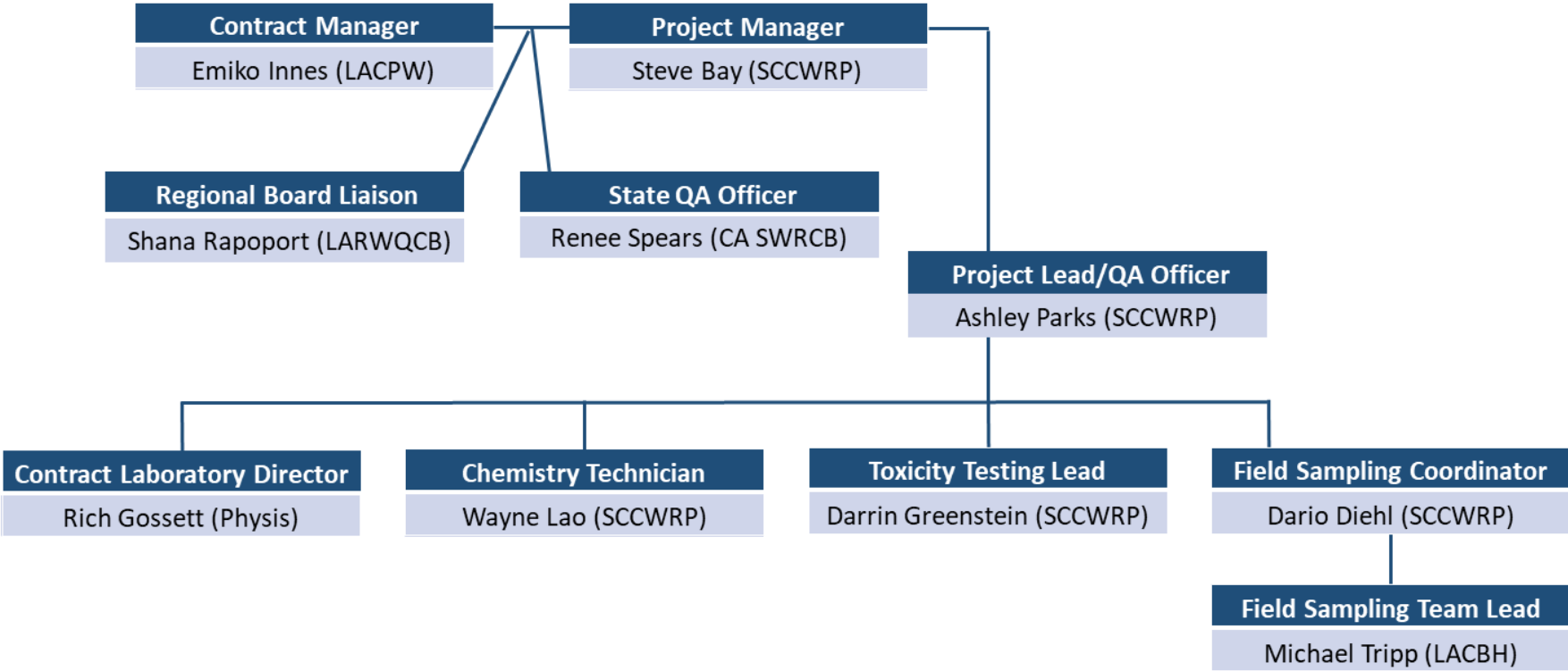


Figure 1. Organization Chart

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1.5 Problem Definition/Background

In 1998, the back basins of MdR Harbor were placed on the 303(d) list for contaminants impacting sediment, fish tissue, and benthic infauna. At this time, pollutants of concern for sediment included DDT, chlordane, lead, copper, and zinc and pollutants of concern for fish tissue included those for sediment and PCBs, dieldrin, and tributyltin (TBT). The MdR Harbor Toxics TMDL was promulgated in 2005 to address impairments associated with sediment for copper, lead, zinc, chlordane, PCBs, and toxicity and fish tissue for DDT, dieldrin, chlordane, PCBs, and fish consumption advisory (Los Angeles RWQCB/USEPA 2005). Monitoring and special studies conducted in support of the Toxics TMDL have since provided additional information regarding the spatial extent and magnitude of the impairments. The results have shown that dissolved copper concentrations frequently have exceeded the chronic (4-day average) criterion (also referred to as Criterion Continuous Concentration [CCC]) of 3.1 micrograms per liter ($\mu\text{g/L}$), as specified in the California Toxics Rule (CTR).

The Toxics TMDL was revised and adopted by the Los Angeles Regional Water Quality Control Board (RWQCB) in February 2014 (Los Angeles RWQCB 2014) and was subsequently approved by the State Water Resources Control Board (SWRCB) in September 2014 (SWRCB 2014). Toxics TMDL revisions were designed to take into consideration new data on the spatial extent and magnitude of sediment contamination as well as address the dissolved copper CTR exceedances in the water column. As such, the Toxics TMDL includes load allocations for dissolved copper required to ensure that dissolved copper concentrations in MdR Harbor are less than the CCC criterion in the CTR.

Although there are exceedances of the dissolved copper CCC in MdR Harbor, the concentration threshold necessary to protect aquatic life in MdR Harbor is uncertain. It is well known that water quality parameters (e.g., pH, dissolved organic carbon [DOC], and salinity) influence the biological availability of copper in marine water and may reduce the potential to cause toxicity to aquatic life (USEPA 1994; Di Toro et al. 2001). The federal water quality criteria (from which the CTR criteria were derived) for dissolved copper were developed to be conservative to protect marine aquatic life in all waters of the U.S. regardless of site-specific water characteristics. Specifically, water quality criteria were developed based on laboratory studies in which filtered seawater was used, and consequently, these studies do not necessarily account for many of the physical constituents (e.g., particulate and dissolved organic matter) that may interfere with the toxicity of potential chemicals of concern, such as copper. Consequently, the USEPA has developed procedures that can be performed to develop water quality criteria that are specific and reflective of site-specific conditions, while still providing the required level of protection for aquatic life.

In SWRCB Resolution 2014-0049 (SWRCB 2014), the SWRCB recognizes that the U.S. Environmental Protection Agency (USEPA)-approved Water-Effect Ratio (WER) method may be used to derive site-specific water quality objectives and if adopted by the Los Angeles RWQCB and approved by the SWRCB Office of Administrative Law and USEPA will supersede the current CTR CCC criterion as the

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water quality standard for dissolved copper in MdR Harbor. Conditional approval to conduct an SSO study for Marina del Rey Harbor was granted by the Los Angeles RWQCB in September 2017 (revised in June 2018).

The objective of this study is to develop a scientifically defensible SSO for MdR Harbor that accounts for site-specific conditions and is as protective of aquatic life and the beneficial uses of MdR Harbor as is intended by the current criteria.

1.6 Project/Task Description and Schedule

The key elements and sequence of the study design development are shown in Figure 2. Toxicity testing will be the primary method used to calculate WERs. Toxicity tests will be conducted using embryos of the mussel, *M. galloprovincialis*. This species is recommended for WER calculation in the USEPA (1994) Interim Guidance and has been the primary or sole species used for WER development in recent studies in San Francisco Bay (San Francisco Bay RWQCB 2007) and San Diego Bay (Bosse et al. 2014). *M. galloprovincialis* is an ideal organism for use in WER copper studies because of its sensitivity to copper and commercial importance.

The study design is based on the conceptual approach outlined in the USEPA (1994) Interim Guidance and includes key design elements used in three recent WER studies conducted in California. The USEPA (1994) Interim Guidance recommends that WER analyses be conducted over a range of conditions so that the results are representative of the variations in water quality at the site. The guidance also states that the study should include multiple stations distributed over a minimum of three separate sampling events that include different seasons and locations. The schedule for this study is outlined in Table 1.

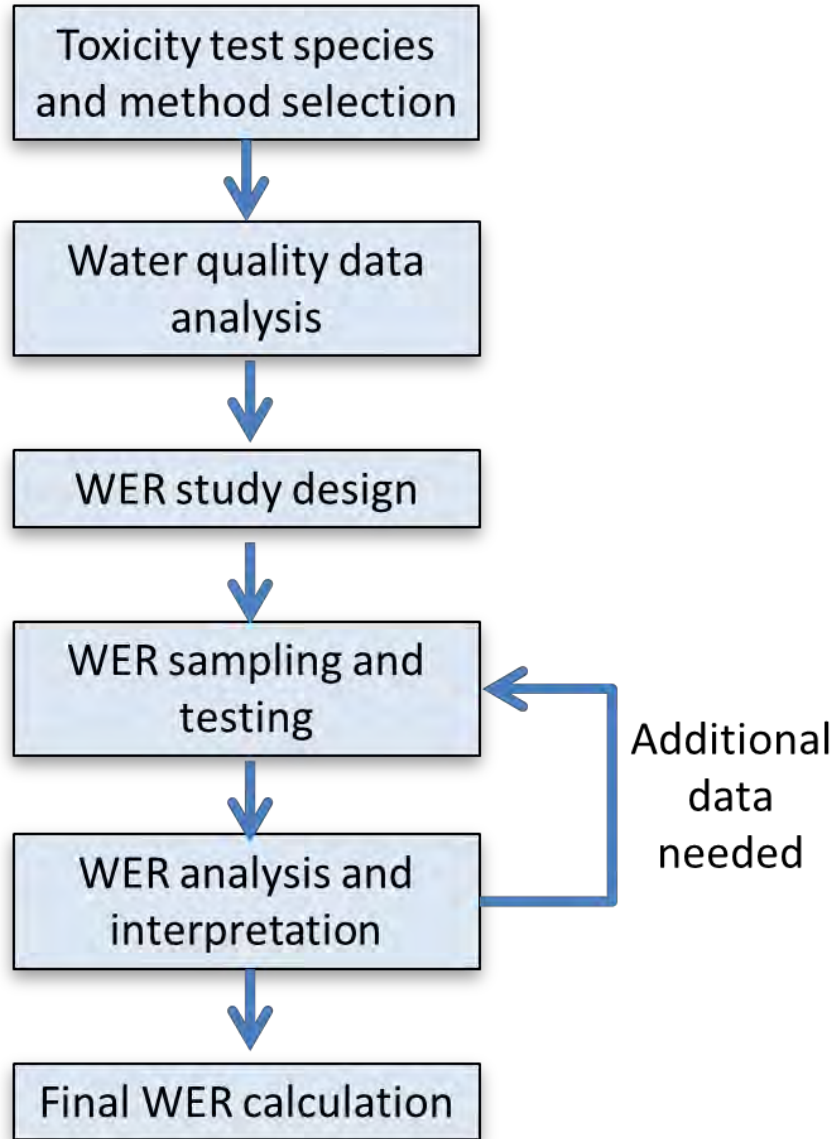


Figure 2. Study elements and process.

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Table 1. Site-specific objective study schedule

Deliverables	Target Date ¹
Review of work plan by stakeholders	November 2018
TAC Meeting 1: Review of work plan ²	December 2018
Submission of revised SSO Work Plan for Los Angeles RWQCB concurrence	March 2019
TAC Meeting 2: conference call to discuss work plan revisions	April 2019
Preparation of QAPP	June 2019
Public Outreach Workshop 1: Study background and description of work plan	July 2019
QAPP revision and review	June-July 2019
WER Sampling and Testing	July 2019 June 2020
TAC Meeting 3: conference call to discuss interim results of WER analyses	October 2019
TAC Meeting 4: conference call to discuss interim results of WER analyses	December 2019
TAC Meeting 5: conference call to discuss preliminary WER results	June 2020
SSO Draft Report and Implementation Draft Report	July 2020
Public Outreach Workshop 2: Presentation of report findings to stakeholders	August 2020
TAC Meeting 6: conference call to discuss TAC's review of the draft report	August 2020
TAC Meeting 7: discussion of revised SSO Final Report	September 2020
Final SSO and Implementation Reports	October 2020

Notes:

RWQCB = Regional Water Quality Control Board

SSO = site-specific objective

TAC = Technical Advisory Committee (all TAC meetings will be open to stakeholder participation)

WER = Water Effect Ratio

- 1 Dates are for planning purposes only; specific dates for meetings have not yet been established.
- 2 An orientation conference call with the TAC will be held prior to the December meeting.

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1.7 Quality Objectives and Criteria for Measurement Data

1.7.1 Objectives and Project Decisions

The data quality objectives (DQOs) for this project are to ensure that data collected are of known and acceptable quality. The quality of laboratory data is assessed by precision, accuracy, and completeness. Definitions of these parameters and the applicable QC procedures are given below. Frequency of QC samples and quantitative levels are described in subsequent sections.

Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling, and laboratory analysis. In the laboratory, "within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. "Batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or LCSs from multiple analytical batches. Field precision will be evaluated by collecting blind field duplicates for chemistry samples. Field chemistry duplicate precision will be screened against an RPD of 25 percent. However, no data will be qualified based solely on field duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the MDL, where the percent error (expressed as RPD) increases. The equation used to express precision is as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

Where:

RPD = relative percent difference

C₁ = larger of the two observed values

C₂ = smaller of the two observed values

Accuracy

Accuracy is a measure of the closeness of a measurement to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, LCMs, and standard solutions. In addition, laboratory-fortified (i.e., MS) samples will be measured; this sample type indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (%R) of the measured value, relative to the true or expected value. If a measurement process produces results which are not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination). Analytical laboratories use several QC measures to eliminate analytical bias, including systematic analysis of method blanks, LCSs, and independent calibration verification standards. Because bias can be positive or negative,

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and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

Laboratory accuracy will be evaluated against quantitative laboratory control sample, MS, and surrogate spike recovery performance criteria provided by the laboratory. Accuracy can be expressed as a percentage of the true or reference value, or as a %R in those analyses where reference materials are not available and spiked samples are analyzed.

The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa}$$

Where:

- %R = percent recovery
- S = measured concentration in the spiked aliquot
- U = measured concentration in the unspiked aliquot
- C_{sa} = concentration of spike added

Field accuracy will be controlled by adherence to sample collection procedures outlined in the sample collection sections of this QAPP.

Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = [(Number\ of\ acceptable\ data\ points) \times 100] / (Total\ number\ of\ data\ points)$$

The DQO for completeness for all components of this project is 95 percent. Data qualified as estimated because QC criteria were not met will be considered valid for the purpose of assessing completeness. Data qualified as rejected will not be considered valid for the purpose of assessing completeness.

Sensitivity

Analytical sensitivities must be consistent with, or lower than, the values listed in Table 2 in order to demonstrate compliance with this QAPP. When achievable, target reporting limits specified will be at least a factor of 2 less than the analyte's corresponding target criteria.

The method detection limit (MDL) is defined as the minimum concentration at which a given target analyte can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. Laboratory reporting limits (RLs) are defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. Laboratory MDLs and RLs will be used to evaluate the method sensitivity and/or applicability prior to the acceptance of a method for this program.

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The sample-specific MDL and RL will be reported by the laboratory and will take into account any factors relating to the sample analysis that might decrease or increase the RL (e.g., dilution factor, percent moisture, sample volume, or sparge volume). In the event that the MDL and RL are elevated for a sample due to matrix interferences and subsequent dilution or reduction in the sample aliquot, data will be evaluated to determine if an alternative course of action is required or possible. The sample-specific RL will be provided in the project database.

1.7.2 Action Limits/Levels

Detection and reporting limits for laboratory measurements are listed in Table 2. Detection and reporting limits are not applicable for the field measurements.

Table 2. Analytical Methods and Detection Limits

Parameter	Analytical Method	Method Detection Limit	Reporting Limit
Dissolved Organic Carbon (mg/L)	USEPA 9060a	0.055	0.055
Total and Dissolved Metals ($\mu\text{g/L}$)			
Copper	USEPA 1640	0.005	0.15
Zinc	USEPA 1640	0.0025	0.15

Notes:

$\mu\text{g/L}$ = micrograms per liter mg/L = milligrams per liter

USEPA = U.S. Environmental Protection Agency

1.7.3 Measurement Performance Criteria/Acceptance Criteria

Field measurement quality objectives include calibration and measurement accuracy for measurements including dissolved oxygen, pH, temperature, or salinity. Table 3 summarizes the measurement quality objectives for field measurements. Field QC samples will also be collected and analyzed by the laboratory as indicated in Table 4. The toxicity test data quality objectives are summarized in Table 5.

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Table 3. Field Measurement Quality Objectives

Parameter	Measurement Accuracy
Salinity (g/kg)	± 0.1 g/kg
Temperature (°C)	± 0.2 °C
pH (su)	± 0.2
Dissolved Oxygen (mg/L)	± 1 %

g/kg = grams per kilogram
 mg/L = milligrams per liter
 su = standard unit

Table 4. Data Quality Objectives

Parameter	Precision	Accuracy ¹	Completeness
Dissolved Organic Carbon	± 25% RPD	75-125% R	95%
Total and Dissolved Metals	± 25% RPD	75-125% R	95%

R = recovery

RPD = relative percent difference

¹ Laboratory reference material and/or matrix spike/matrix spike duplicate percent recovery

Table 5. Toxicity Data Quality Objectives

Paramet	Limit
Control Mean Normal Development	≥90%
Control Mean Survival	>50%
Percent Minimum Significant Difference	<25%

1.8 Special Training Requirements/Certification

Metals analysis will be conducted at Physis, which is accredited under California's Environmental Laboratory Accreditation Program ELAP (CA ELAP; Certificate No. 2769). Toxicology personnel are trained in the standard toxicity test methods by the Laboratory Manager (Darrin Greenstein). A previously recorded video from the Bight 2008 intercalibration study is provided as additional training for proper embryo development

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identification. Prior to sample analysis, an intercalibration exercise is performed to ensure the same results are obtained from multiple technicians when counting the normal and abnormal mussel embryos in several test samples.

Additional specialized training for field sampling or toxicity testing technicians is provided by the Field Sampling Coordinator or Toxicity Testing Lead, respectively. Documentation of any additional training will be kept by the appropriate Coordinator/Lead.

1.9 Documents and Records

1.9.1 QA Project Plan Distribution

The most current approved QAPP will be distributed electronically by email to each of the individuals identified in Section 1.3. The field and analytical leads will be responsible for communicating relevant aspects of the QAPP to technical staff under their supervision.

1.9.2 Field Documentation and Records

All field activities will be recorded on field forms logged by field staff. Field forms will provide a description of sampling activities, a list of sampling personnel, weather conditions, and a record of all modifications to the procedures and plans identified in this QAPP if necessary. Field information will be recorded as shown in Attachment A of this QAPP (Field Sampling Forms, Pages 47 - 50).

The following forms, included as Attachment A of this QAPP, will be used to record pertinent collection, processing, and sampling information:

- Chain-of-custody (COC) form (Page 50)
- Daily log and sampling form (Page 47)
- Water profiling instrument calibration form (Page 48-49)

1.9.3 Laboratory Documentation and Records

Chemistry

Analytical data records will be retained by the laboratory and in the project files. For all analyses, data reporting requirements will include items necessary to complete data validation. Laboratory analytical reports will be provided in electronic format, including the scanned PDF of the report and the Electronic Data Deliverable (EDD). The analytical laboratory will be required, where applicable, to report the following:

- Project Narrative. This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but is not be limited to, QC, sample shipment, sample storage, and analytical

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difficulties. Any problems encountered, actual or perceived and their resolutions will be documented in as much detail as appropriate. The narrative should also include final dilution volumes for all samples analyzed at a dilution in which one or more analytes is reported as not detected.

- COC Records. Legible copies of COC forms will be provided. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.
- Sample Results. Results for each sample analyzed will be provided. The summary will include the following information when applicable:
 - Field sample identifier and the corresponding laboratory identification code
 - Sample matrix
 - Date of sample preparation
 - Date and time of analysis
 - Identification of the instrument used for analysis
 - Analytical results with reporting units identified
 - Data qualifiers and their definitions
- QA/QC Summaries. Results of the laboratory QA/QC procedures will be provided. Each QA/QC sample analysis will be documented with the same information required for sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested.
 - Method Blank Analysis. The method blank analysis associated with each sample and the concentration of all compounds of interest identified in these blanks will be reported.
 - MS Recovery. MS recovery data will be included. The name and concentration of all compounds added, %R, and range of acceptable recoveries will be listed. The recoveries and RPD for all MS duplicate analyses will be reported.
 - Laboratory Duplicate. The RPD for all laboratory duplicate analyses will be included.
 - Laboratory Control Sample. All laboratory control sample recovery data will be included. The name and concentration of all compounds added, %R, and range of acceptable recoveries will be listed. The recoveries and RPD for all laboratory control sample duplicate analyses will be reported.

All instrument data will be fully restorable at the laboratory from electronic backup.

Laboratories will be required to maintain all records relevant to project analyses for a

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minimum of 7 years. Data validation reports will be maintained in the project files with the analytical data reports.

Toxicity

Toxicity test reports will be retained by the laboratory and stored electronically in the project files. The laboratory will be required, where applicable, to report the following:

- **Test Methods.** A summary of test conditions for each test will be included. All methods should be in accordance with guidelines described in the Work Plan and other guidance or as otherwise noted in the Work Plan.
- **Test Results.** Results will include a summary of the following information:
 - Test dates
 - Source of control material
 - Source of organisms
 - Water quality measurements
 - Appropriate lethal or sublethal endpoint results for each species
 - LC50 or EC50
 - Control acceptability statement
 - Summary of reference toxicant test results
- **Statistical Analyses.** Statistical analyses will be performed to determine the median effective concentration (EC50), or the statistically derived concentration indicative of toxic effects in 50% of test organisms under specific test conditions.
- **QA/QC Summaries.** The results of a QC review, with any protocol deviations and corrective actions taken, will be provided.
- **Raw Data.** Legible copies of raw datasheets used in testing, including water quality, daily observations, and final lethal or sublethal endpoint results, will be provided.
- **Reference Toxicant Test Data.** Raw datasheets, statistical analyses, and control charts comparing current test results with historical test results will be provided.
- **COC Records.** Legible copies of the COC forms will be provided. Forms will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.

1.9.4 Quarterly and/or Final Reports

Interim progress reports and data summaries will be provided as specific study tasks are completed. The format and content of these reports will vary, according to the nature of the

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activity. Preliminary data and reports will be made available to stakeholders when they are sent to the TAC for review.

The results of the SSO tasks will be summarized, integrated, and evaluated in a draft report. The final dataset will be provided to LACPW in CEDEN format. Laboratory reports, copies of field forms, and data validation reports will be included as appendices.

The draft study report (two hard copies and an electronic copy) will be prepared for LACDPW review and comment. Following receipt of comments and revisions to the draft report, a draft final report will be prepared for review by the TAC, RWQCB, and other public agencies. All comments will be reviewed and addressed, and a final report will be prepared and provided to LACDPW (three hard copies and an electronic copy).

Following the completion of the SSO final report, an implementation report will be developed in coordination with LACDPW and the regulatory agency in order to incorporate the SSO study results in an amendment to the Basin Plan and the Toxics TMDL. The implementation report will include recalculations of TMDL numeric targets for dissolved copper in Mdr Harbor; i.e., chronic CCC and acute CMC will be recalculated using fWERs specific to Mdr Harbor.

A draft implementation report (electronic copy) will be submitted to LACPW and the RWQCB staff for review. All comments will be reviewed and addressed accordingly. A final implementation report will be submitted to the LACPW (3 hard copies, 1 electronic copy). A copy of the final implementation report will be also submitted to the RWQCB E.O.

2 DATA GENERATION AND ACQUISITION

2.1 Sampling Design (Experimental Design)

The station locations for the study are a subset of 11 candidate stations used in previous monitoring surveys (Table 6). These stations include nine locations used for metals analysis in the Mdr Harbor TMDL Coordinated Integrated Monitoring Program (CIMP; Weston 2014), consisting of one station in each of the harbor's eight basins (MdrRH-A through H) and one station at the end of the main channel (MC1). These stations were augmented by adding two additional main channel stations, located near the harbor entrance and near the mid-point of the channel. All 11 stations were sampled in 2018 in a site characterization study to document variations in harbor water quality associated with factors such as urban runoff, boat density, water circulation, and shipyard activities.

Based on the 2018 water quality results, a subset of five stations is recommended for WER analysis (Figure 3), with composite samples being collected from three locations in each of the four selected basins. These stations represent locations where DOC concentrations are likely to be lowest (main channel station 3, front basins A and B), as well as locations where

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DOC and copper concentration are likely to be high (back basins E and F). Additionally, these locations encompass many of the major stormwater outfalls in the Harbor and should provide representative results during wet weather sampling. Sampling these stations at multiple times throughout the year is expected to represent variations in water quality factors controlling copper bioavailability throughout the Harbor, as well as encompassing the critical condition during each sampling event.

Six sampling events are proposed for WER calculation (Table 7). The events will be distributed over an approximately 12-month period to capture major seasonal variations in water quality. Most of the sampling events (4 or 5 events) will occur during dry weather, when the critical condition is expected to be present. To ensure spatial representativeness, the samples collected from the four basin locations will be composites of the end, middle, and mouth of the basin (Figure 3).

Effects of tidal variation will be documented by conducting dry weather sampling during both spring tides (high variation between low and high tide) and neap tides (low difference between low and high tide). During dry weather, each of the five locations will be sampled twice in one day: once during flood tide and once during ebb tide. These two samples will be composited together such that one final sample per station is collected for chemical and toxicity analysis. The compositing over space and time during each sampling event is intended to increase the representativeness of the data for describing conditions in the Harbor.

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Table 6. Station locations

Station ID	Description	Latitude	Longitude
MdRH-MC1	Main Channel, end	33.98054	-118.44819
MdRH-MC2	Main Channel, middle	33.97231	-118.448
MdRH-MC3	Main Channel, entrance	33.96427	-118.455
MdRH-A	Front Basin A, middle	33.97251	-118.45284
MdRH-B	Front Basin B, middle	33.97514	-118.45346
MdRH-C	Front Basin C, middle	33.97773	-118.45372
MdRH-D	Back Basin D, middle	33.98022	-118.45356
MdRH-E	Back Basin E, middle	33.98301	-118.45338
MdRH-F	Back Basin F, middle	33.98198	-118.44502
MdRH-G	Front Basin G, middle	33.97939	-118.44435
MdRH-H	Front Basin H, middle	33.97635	-118.44409

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Table 7. Proposed water-effect ratio sampling events.

Event	Tide Type		Summer	Winter	
			Dry Weather	Dry Weather	Wet Weather
	Spring	Neap	April – October	November – March	November – March
1	X		X		
2	X			X	
3		X	X		
4		X		X	
5	NA	NA			X
6*	TBD	TBD	TBD	TBD	TBD

Notes:

Wet weather sampling is not dependent on tide type. Sampling event characteristics to be determined based on results of previous events.

NA = not applicable

TBD = to be determined

*The details of Event 6 will be based on review of data from the prior events and discussion with stakeholders and the TAC.

Several water quality parameters (e.g., pH, temperature, dissolved oxygen, and salinity) will be measured using probes in the field at the time of water sampling. Grab samples of water will be collected 1 m below the water surface at each station for measurement of DOC, metals, and toxicity. Concentrations of both copper and zinc will be measured, as both metals may be elevated in harbors and contribute to ambient toxicity.

All water samples will be tested for toxicity and WER calculation using a 48-hour exposure of mussel embryos under standard conditions as described by USEPA (1995). Water from each MdR Harbor station and the laboratory control will be spiked to generate a series of copper concentrations designed to produce toxicity results ranging from no effect to complete inhibition of normal embryo development.

The USEPA (1994) Interim Guidance on calculating the WER and interpreting results will be followed in this study. Generally, the EC50 will be determined using the Trimmed Spearman-Kärber method. The sample WER (sWER) will be calculated as the ratio of the sample EC50 divided by the control EC50. The sWERs for different stations and events will be summarized and evaluated to determine if the results are sufficient for calculation of the final WER (fWER).

2.2 Sampling Methods

Procedures for collection of field samples and associated QC samples, as well as sample volumes, and container types are summarized in Tables 8 and 9, with more details described on in Sections 2, 3, and 4 of Attachment A of this QAPP.

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Table 8. Sample Containers, Holding Times, and Preservation Methods

Parameter	Sample Size	Container Size and Type	Holding Time	Preservative
Dissolved Organic Carbon	40 mL	Pre-combusted glass vial (40 mL)	28 days	Cool/4°C; HCl pH<2
Total Metals	50 mL	Centrifuge tube (50 mL)	6 months	Cool/4°C; HNO ₃ to pH<2
Dissolved metals	50 mL	Centrifuge tube (50 mL)	6 months	Cool/4°C; HNO ₃ to pH<2 after filtration

Notes:
 Dissolved samples will be field
 filtered
 mL = milliliters

Table 9 Frequencies for Quality Assurance/Quality Control Samples

Analysis Type	Initial Calibration	Ongoing Calibration	Duplicates	Matrix Spikes	LCS/LCM	Method Blanks	CRM
Dissolved Organic Carbon	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	Each batch	Each batch
Total and Dissolved Metals	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	Each batch	Each batch

Notes:
 LCM = laboratory control material
 LCS = laboratory control sample
 CRM = certified reference material

2.3 Sample Handling and Custody

Samples will be identified with a sample identifier that specifies the waterbody or site (Marina del Rey Harbor [MdrH]), basin or station location, and sample number. An example sample identifier for the sample collected from Basin E, would be:

MdRH-E

An example sample identifier for a quality control sample taken at Basin H would be:

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Field Blank
 or
 Matrix
 Spike (H)

An example sample identifier for a field duplicate sample collected from Basin E, would be:

MdRH-E-Dup

Each sample will have a waterproof paper label affixed to the container and will be labeled at the time of collection. The following information will be recorded on the container label at the time of collection:

- Project name
- Sample identifier
- Analysis to be performed
- Analysis Laboratory
- Date of sample collection

An example label would be:

Project: MDR SSO

Sample ID: MdRH-E

Analysis: Total Metals Laboratory: Physis

Date: August 3, 2019

Samples are considered to be in one's custody if they are in the custodian's possession or view or in a secured location with restricted access. COC procedures will be followed for all samples throughout the collection, handling, and analysis process. The principal document used to track possession and transfer of samples is the COC form. Each sample will be represented on a COC form the day it is collected. All entries on the COC form will be made using indelible ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, and dating and initialing the change. Blank lines/spaces on the COC form will be lined-out, dated, and initialed by the individual maintaining custody.

A COC form will accompany each group of samples to the analytical laboratory. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Copies of all COC forms will be retained in the project files. Each cooler containing samples for analysis will be hand-delivered to Physis Environmental Laboratories, Inc. (Physis) the same day of sample collection or the following morning. In the event that Saturday delivery is required, the field coordinator(s) will contact the

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analytical laboratory on Friday to ensure that the laboratory is aware of the number of samples to be transferred. Following each shipment, the field coordinator(s) will call the laboratory and verify the shipment from the day before was received and is in good condition. Samples will be packed with ice to maintain recommended storage temperatures of 4°C and a thermometer will be included to measure temperature. Ice will be sealed in separate double plastic bags and placed in the transportation coolers. Individual sample containers will be placed in a sealable plastic bag, packed to prevent breakage, and transported in an ice chest or other suitable container. The shipping containers will be clearly labeled with sufficient information (name of project, time and date of collection, and contact person) to enable positive identification.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the COC form. Upon receipt of samples at the laboratory, the receiver will record the condition of the samples on a sample receipt form. COC forms will be used internally in the laboratory to track sample handling and final disposition.

2.4 Analytical Methods

Methods for laboratory analyses for chemistry and toxicity are described in Attachment B of this QAPP.

2.4.1 Field Measurements Methods

These methods are described on page 41 of Attachment A of this QAPP.

2.4.2 Field Analyses Methods

There will be no field analyses in this study.

2.4.3 Laboratory Analyses Methods (Off-Site)

Methods for contract laboratory analyses are described on page 54 for analytical testing and page 64 for toxicity testing of Attachment B of this QAPP.

2.5 Quality Control Requirements

2.5.1 Field Sampling Quality Control

Field data forms will be checked for completeness and accuracy by the field coordinator(s) prior to delivery to the project manager(s) and disbursement to rest of the project team. Original forms will be retained and filed in a project binder after data entry and checking are complete.

2.5.2 Field Measurement/Analysis Quality Control

2.5.2.1 Field Measurement QC

The QC checks for field sampling/analyses are described in Section 5 and 6 of Attachment A of this QAPP.

2.5.2.2 Field Analysis QC (Screening and Definitive)

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This section is relevant to conducting quantitative analysis while in the field, therefore not applicable to the current study.

2.5.3 Laboratory Analysis Quality Control

The QC checks for laboratory analyses are described on page 58 for analytical testing and page 67 for toxicity testing of Attachment B of this QAPP.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

2.6.1 Field Measurement Instruments/Equipment

A description of the field measurement instruments/equipment is included on page 41 of Attachment A of this QAPP.

2.6.2 Field Instruments/Equipment (Screening and Definitive)

This section not applicable to the current study.

2.6.3 Laboratory Analysis Instruments/Equipment (Off-Site)

See page 53 for analytical testing and page 61 for toxicity testing of Attachment B of this QAPP.

2.7 Instrument/Equipment Calibration and Frequency

2.7.1 Field Measurement Instruments/Equipment

See Section 5 and 6 of Attachment A of this QAPP.

2.7.2 Field Instruments/Equipment (Screening and Definitive)

This section not applicable to the current study.

2.7.3 Laboratory Analysis Instruments/Equipment (Off-Site)

See page 53 for analytical testing and page 61 for toxicity testing of Attachment B of this QAPP.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables

2.8.1 1 Field Sampling Supplies and Consumables

See Section 5 and 6 of Attachment A of this QAPP.

2.8.2 Field Measurement/Analyses (Screening and Definitive) Supplies and Consumables

This section will not require field measurement/analyses supplies and consumables.

2.8.3 Laboratory Analyses (Off-Site) Supplies and Consumables

See page 53 of Attachment B of this QAPP.

2.9 Data Acquisition Requirements (Non-Direct Measurements)

This project will not require the use of non-direct data.

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2.10 Data Management

Data management will involve compiling data collected as part of the SSO study into standardized formats, data review, and export of field, toxicity test, and chemistry data as flat files that are accessible by Los Angeles County Public Works (LACPW). Data will be reviewed for quality and completeness, compiled, and exported in CEDEN format to LACPW. The data will be submitted to CEDEN by LACPW. Field data forms will be checked for completeness and accuracy by the field coordinator(s) prior to delivery to the project manager(s) and disbursement to rest of the project team. Original forms will be retained and filed in a project binder after data entry and checking are complete. Analytical chemistry data will be submitted by the laboratory in specified PDF and electronic data deliverable formats. Analytical data will undergo verification and validation in accordance with the QAPP and final validation qualifiers will be applied and stored. A concise data validation summary will be prepared and included in the final report.

All toxicity test data including laboratory bench sheets and randomization sheets will be reviewed to ensure that data meet QA/QC standards specified in the standard method guidance documents. A determination will be made as to whether DQOs were met by assessing test acceptability criteria, reference toxicant test results, protocol deviations (i.e., water quality deviations), sample handling notes, and data completeness. Minor data quality issues, that likely do not affect the test outcome, will be noted and summarized in the final report. Database contents will be compared to bench sheets to ensure that the electronic data are complete and accurate.

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate data analysis. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce data, which are subjected to further review by the laboratory manager, the project manager, and independent reviewers. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

A draft Excel database containing data collected during the first half of the SSO study will be provided before the end of 2019. A final Excel database containing field sampling coordinates, field water quality measurements, compiled validated analytical data, and compiled toxicity summary data for the entire study will be provided along with the final report.

3 ASSESSMENT AND OVERSIGHT

3.1 Assessments/Oversight and Response Actions

The Project Lead/QA Officer will review field sampling and toxicity testing records at the end of each event/test to verify adherence to QA procedures. Toxicity and chemistry data reports will

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be reviewed promptly upon receipt from the laboratory lead for compliance with DQOs, completeness, apparent outliers requiring confirmation.

The QA officer has the authority to request reanalysis of chemistry or toxicity samples to correct QC issues. Such actions will be undertaken following notification and concurrence by the Project Manager.

3.2 Reports to Management

The QA Officer will provide verbal or status written reports to the Project Manager at the end of each sampling/analytical event. These reports will summarize the QA/QC assessment results and completion status of the event. If significant QA issues are present, then the report will include recommended steps to correct the issue.

The Project Manager will provide quarterly project status reports to the Contract Manager, which include information on overall project status and significant quality assurance problems.

4 DATA REVIEW AND USABILITY

4.1 Data Review, Verification, and Validation Requirements

QC data will be compared to the data quality objectives and holding times (Sections 1.7.3 and 2.2) to establish data validity.

4.2 Verification and Validation Methods

During the validation process, analytical data will be evaluated for method QC and laboratory QC compliance, and their validity and applicability for program purposes will be determined. Based on the findings of the validation process, data validation qualifiers may be assigned. Validated project data, including qualifiers, will be entered into the Excel project database, thus enabling this information to be retained or retrieved as needed.

Data validation includes review for completeness and accuracy by the field coordinator(s) and laboratory manager; review by the QA/QC manager (or designee) for outliers and omissions and the use of QC criteria to accept or reject specific data. All data will be entered into the Excel project database.

Laboratory data will be reviewed and verified to determine whether all DQOs have been met and that appropriate corrective actions have been taken, when necessary. Calculations will be verified by the laboratory. The project manager or designee will be responsible for the final review of all data generated from sample analyses.

The first level of review will take place in the laboratory as the data are generated. The laboratory manager (or designee) will be responsible for ensuring that data generated meet minimum QA/QC requirements and that the instruments were operating under acceptable

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conditions during data generation. DQOs will also be assessed at this point by comparing the results of QC measurements with pre-established criteria as a measure of data acceptability.

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present. A Stage 2A data quality review will be performed in accordance with EPA National Functional Guidelines (USEPA 2010, 2014) by considering the following:

- Holding times
- Method blanks
- Detection limits
- RLs
- LCS/LCMs
- MS/MSD samples

Data will be validated in accordance with the project-specific DQOs described above, analytical method criteria, and each laboratory's internal performance standards based on their SOPs.

4.3 Reconciliation with User Requirements

The sample results will be compared to DQOs to assess precision, accuracy, and completeness. Deviations from DQOs that cannot be resolved by reanalysis will be noted and presented to the Project Manager and Technical Advisory Committee (TAC) for evaluation regarding suitability to meet project objectives. Screening for data anomalies or outliers will be accomplished by comparing results to historical baseline values or expectations from comparable studies. Statistical outlier detection methods may be used. The ranges and variability (standard deviation) of calculated WERs will be evaluated by the TAC for suitability for meeting the study objectives and to assess whether data use should be limited. Additional sampling or analyses may be recommended by the TAC to resolve significant data anomalies or limitations.

5 REFERENCES

- Bosse, C., G. Rosen, M. Colvin, P. Earley, R. Santore, and I. Rivera-Duarte, 2014. Copper bioavailability and toxicity to *Mytilus galloprovincialis* in Shelter Island Yacht Basin, San Diego, California. *Marine Pollution Bulletin*, 85:1634-1640. USEPA, 2010.
- Di Toro, D.M., H.E. Allen, H.L. Bergman, J.S. Meyer, P.R. Paquin, and R.C. Santore, 2001. Biotic ligand model of the acute toxicity of metals. Technical basis. *Environmental Toxicology and Chemistry*, 20: 2383-2396.
- Los Angeles RWQCB, 2014. State of California Regional Water Quality Control Board, Los Angeles Region. Resolution No. R14-004. Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise the Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor. February 6, 2014.

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Los Angeles RWQCB/USEPA (Los Angeles Regional Water Quality Control Board and U.S. Environmental Protection Agency), 2005. Total Maximum Daily Load for Toxic Pollutants in Marina Del Rey Harbor. October 6, 2005.

San Francisco Bay RWQCB, 2007. Copper Site-Specific Objectives in San Francisco Bay. Proposed Basin Plan Amendment and Draft Staff Report. June 6, 2007.

SWRCB (State Water Resources Control Board), 2014. Resolution No. 2014-0049. Approving an Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise a Total Maximum Daily Load for Toxic Pollutants in Marina del Rey Harbor. September 9, 2014. Available from:
http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/tmdl/tmdl_list.shtml.

USEPA (U.S. Environmental Protection Agency), 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. USEPA-823-B-94-001. Office of Water and Office of Science and Technology, Washington, D.C. February 1994.

USEPA, 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review. USEPA Office of Superfund Remediation and Technology Innovation. USEPA 540-R-10-011. January 2010.

USEPA, 2014. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review. USEPA Office of Superfund Remediation and Technology Innovation. USEPA 540-R-013-001. August 2014.

Weston (Weston Solutions, Inc.), 2014. Marina del Rey Watershed Coordinated Integrated Monitoring Program. Prepared for Marina del Rey Enhanced Watershed Management Program Agencies. June 28, 2014.

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QAPP ATTACHMENT A SAMPLING AND FIELD METHODS

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MARINA DEL REY HARBOR SITE-SPECIFIC OBJECTIVE (SSO) STUDY

WATER SAMPLING METHODS

Southern California Coastal Water Research Project

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1 BACKGROUND

This document describes methods for the collection and field processing of water samples from Marina del Rey Harbor for site characterization, toxicity and chemical analyses. The data resulting from these analyses will be used to characterize variations in harbor water quality, calculate Water Effects Ratios for copper, and apply the Biotic Ligand Model to predict copper toxicity.

2 SAMPLE COLLECTION

Water samples will be collected from single or multiple depths (depending on study objective), including one meter above the sediment surface and one meter below the water surface. Provisional sample locations include 11 stations that represent the central areas of each harbor basin and portions of the main access channel (Figure 1, Table 1). Upon station occupation, sampling and processing will occur in the following order: 1) record station location and general conditions in log, 2) collect water samples, 3) process samples, 4) measure water quality parameters (grab samples or profiles), and 5) record sampling data in log.

Water samples will be collected using a peristaltic pump fitted with Teflon-lined tubing. Once the tubing intake is at depth, the pump will be turned on to allow tubing to be flushed. After flushing, two liters of site water will be collected in clean 1 liter fill bottles. Subsampling for subsequent processing of trace metals and organic carbon will come from the fill bottle. The water in the fill bottle will be swirled to homogenize the sample before transferring to the filtering apparatus or sample containers. A “clean hands-dirty hands” technique (see below) will be employed to minimize contamination of samples. Of the two liters of water that will be collected 50 ml will be filtered for dissolved metals and 40 ml more for DOC analysis. All samples will be placed in dark coolers with wet ice for temporary storage. The field crew will not add any preservatives to the samples.

Composite samples may be collected to include spatial or tidal variations in water characteristics. Spatial composite samples will be created by pooling equal volumes of water collected from three regions of a basin (e.g., end, middle, and end). The pooled sample will be subsampled and filtered as needed to generate separate samples for analysis of metals, organic carbon, chlorophyll, and toxicity. Temporal composite samples will also be created to represent potential variations in water quality associated with tidal exchange. These composites will be prepared by pooling spatial composite samples collected at two times during the sampling day: morning and afternoon. Ideally, sampling events should be scheduled so that a different tide stage (ebb or flood) is represented by each spatial composite.

In order to reduce potential contamination, sampling personnel will adhere to the following rules:

- No smoking.
- Never sample near a running vehicle.

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- Do not eat or drink during sample collection.
- Do not breathe, sneeze or cough in the direction of an open sample bottle.
- Each person on the field crew will wear clean clothing that is free of dirt, grease, or other substances that could contaminate the sampling apparatus or sample bottle.

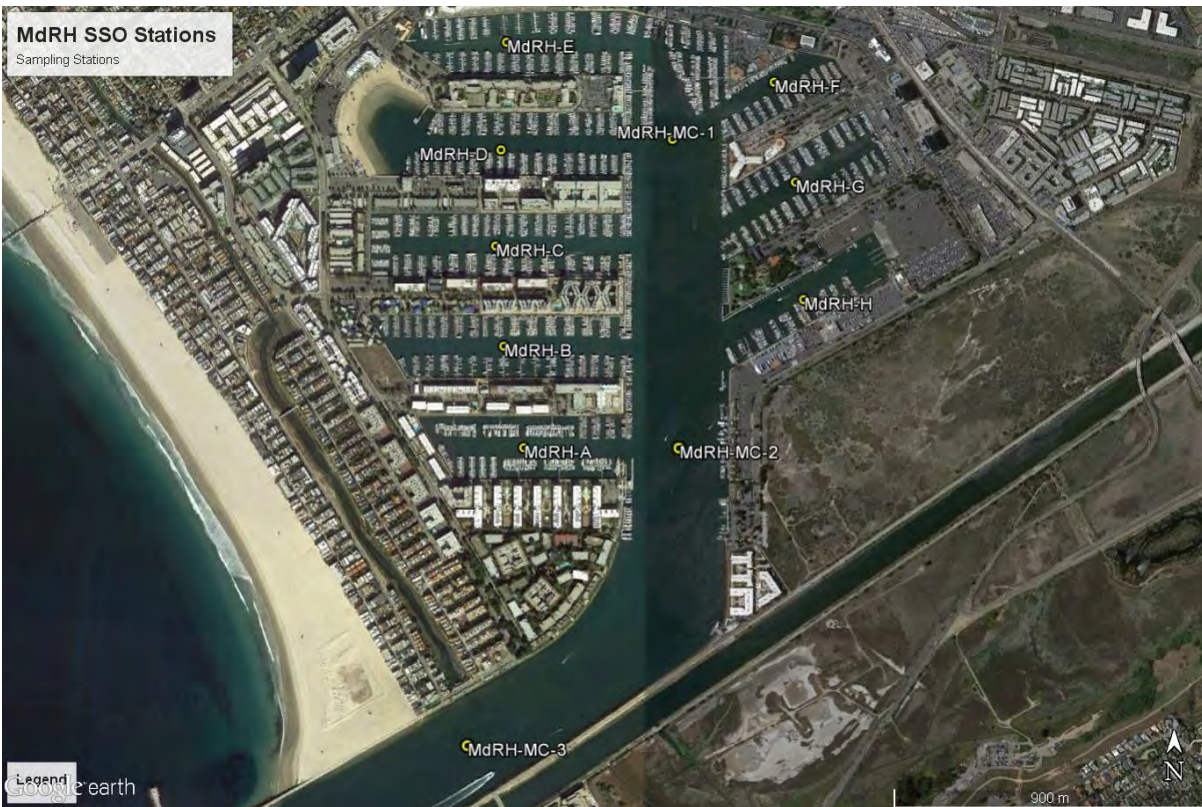


Figure 1. Sampling locations for the study.

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Table 1. Coordinates for sampling locations.

Station ID	Latitude	Longitude
MdRH-MC-1	33.9805	-118.448
MdRH-MC-2	33.97231	-118.448
MdRH-MC-3	33.96427	-118.455
MdRH-A	33.97251	-118.453
MdRH-B	33.97514	-118.453
MdRH-C	33.97773	-118.454
MdRH-D	33.98022	-118.454
MdRH-E	33.98301	-118.453
MdRH-F	33.98198	-118.445
MdRH-G	33.97939	-118.444
MdRH-H	33.97635	-118.444

3 CLEAN SAMPLE HANDLING TECHNIQUES

To prevent contamination of samples, clean metal sampling techniques using USEPA protocols outlined in USEPA Method 1669 will be used throughout all phases of the sampling laboratory work, including equipment preparation, sample collection, and sample handling, storage, and testing. Filled sample containers will be kept on ice or refrigerated until receipt at the laboratory.

The protocol for clean metal sampling, based on USEPA Method 1669, is summarized below:

- Samples are collected in clean sample vials or bottles with any tubing specially processed to clean sampling standards.
- At least two persons, wearing clean, powder-free nitrile or latex gloves at all times, are required on a sampling crew.
- One person, referred to as “dirty hands”, opens only the outer bag of all double-bagged sample bottles.
- The other person, referred to as “clean hands”, reaches into the outer bag, opens the inner bag and removes the clean sample bottle.
- Clean hands rinses the bottle at least two times by removing the bottle lid, filling the bottle approximately one-third full, replacing the bottle lid, gently shaking and then emptying the bottle. Clean hands then collects the sample by filling the bottle and replacing the bottle cap.
- After the sample is collected, the sample bottle is double-bagged in the opposite order from which it was removed from the same double-bagging.
- Clean, powder-free gloves should be changed whenever something not known to be clean has been touched.
- The time of sample collection is recorded on the field log sheet.

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4 SAMPLE PROCESSING

Sample Filtration

A 60 ml plastic syringe with a 0.45 µm filter attached will be used to collect and filter the dissolved metals sample in the field. Each filter apparatus is placed in zip-lock plastic bags and double bagged for storage. The filter material will be tested for Cu and DOC contamination with a field blank. Use one syringe per station. Maintain clean sampling techniques at all times. Double bag each sample container after collection and place it in wet ice for storage until delivery to the analyzing laboratory. The samples will be preserved by the analyzing laboratory.

Dissolved Organic Carbon

Remove the syringe from the storage bag. Next, remove the filter from the bag and screw it tightly onto the tip of the syringe. Rinse the syringe with a small volume of Milli-Q water (10-20 ml) and discard. Pass 50 ml of Milli-Q water through the syringe filter and discard the filtrate. Fill the syringe with sample and discard the first 10 ml of filtrate.

The sample volume for dissolved organic carbon analysis needs to be 40 ml (Table 2). If the filter becomes clogged prior to generating 40 ml of sample, remove and dispose of the used filter and replace it with a new clean filter. For any new filter, repeat the pre-rinse steps described above. Continue to filter the sample. When 40 ml have been collected, cap the sample vial tightly and store on ice for delivery to the analysis laboratory. This sample vial needs to be kept in the dark to prevent sample degradation from exposure to sunlight. The analysis method and detection limits for dissolved organic carbon can be found in Table 3.

Dissolved Metals

A 50 ml sample is needed for dissolved metals analysis (Table 2). Filter the sample using the methods described above. If the filter becomes clogged prior to generating 50 ml of sample, remove and dispose of the used filter and replace it with a new clean filter. Continue to filter the sample. When 50 ml have been collected cap the sample bottle tightly and store on ice for delivery to the analysis laboratory. The analysis method and detection limits for dissolved copper and zinc can be found in Table 3.

Total Metals

The total metals sample does not need to be filtered. Using clean handling techniques, transfer 50 ml of sample to a 50 ml plastic bottle. Double bag the sample and place it on ice after collection. The analysis method and detection limits for total copper and zinc can be found in Table 3.

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Table 2. Sample volumes and storage containers.

Analysis Type	Volume (ml)	Container Type
Dissolved organic carbon	40	Pre-combusted glass vial (40 ml)
Dissolved metals	50	PE tube (50 ml)
Total metals	50	PE tube (50 ml)

Table 3. Analysis methods, method detection limits (MDL) and reporting limits (RL).

Analyte	MDL (µg/L)		RL (µg/L)		Analysis Method
	Total	Dissolved	Total	Dissolved	
Organic Carbon	NA	55	NA	55	EPA 9060a
Copper	0.15	0.15	0.15	0.15	EPA 1640 – FePd only
Zinc	0.15	0.15	0.15	0.15	EPA 1640 – FePd only

5 FIELD MEASUREMENTS AND OBSERVATIONS

Field measurements will be collected, and observations will be made at each sampling site after a sample is collected. All field measurement results and field observations will be recorded on a log sheet similar to the one presented in Figure 2. Field measurements will include either a depth profile or single depth measurement of dissolved oxygen, temperature, salinity, and pH. Measurements will be collected using aYSI multi-probe meter at approximately 0.5 m intervals. Prior to each sampling event, water quality probes will be calibrated using fresh calibration solutions. For all constituents a two-point calibration will be used. After each calibration, the sensor will be checked to verify the accuracy is within 10% of the known value of a standard solution. The calibration process will be repeated until the accuracy is verified.

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MdRH Water Daily Sampling Log

Date _____ Crew _____
Station _____ Latitude _____ Longitude _____
Time at Start _____ Time at Finish _____
Visual Water Description _____
Picture Numbers _____
pH _____ Salinity _____
Temperature _____ Dissolved Oxygen _____
Other Notes _____

Figure 2. Sampling log.

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6 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control (QA/QC) measures will be followed to assure high data quality (Table 4). Field QA/QC for this project includes the following:

Tubing blanks. The use of tubing blanks is intended to test whether contamination is introduced from the collection tubing. Samples of Milli-q water that has passed through the tubing while connected to the pump will be collected for total and dissolved metals as well as DOC analysis. These samples will serve as a blank for the tubing, collection vials, and filtration system prior to field collection. These QA samples will be collected and analyzed once per sampling event. Samples will be collected using clean sampling techniques.

Field blanks. The use of field blanks is intended to test whether contamination is introduced from sample collection and handling, sample processing, or the sample containers. For this blank, laboratory water is processed in the field in the same manner that all the other field samples are processed, excluding the pump tubing. Field blanks will be analyzed for total and dissolved copper and dissolved organic carbon. Clean sampling techniques will be used to process these samples. One field blank sample will be processed per sampling event.

Field duplicates. The use of field duplicates is intended to test the precision of sample collection. Field duplicates will be analyzed for all chemistry constituents. Clean sampling techniques will be used to minimize sample contamination. One field duplicate sample will be processed per sampling event. The station to collect the field duplicate will be chosen during each sampling event.

Travel blanks. Travel blanks are plastic bottles that contain laboratory water to test if contamination is introduced to the samples by the laboratory or transportation methods. Travel blank bottles will be provided by the analytical laboratory and taken into the field at time of sample collection. This bottle will be opened during the time it takes to collect and process one station. They will be returned to the analytical laboratory with the other field collected samples. The analytical laboratory will analyze this water sample for total Cu. Dissolved copper and DOC are not analyzed as this will be reflected in the field blank. One travel blank sample will be processed per sampling event.

Matrix Spike Blanks. Additional water samples will be collected for the analysis of matrix spike samples. The matrix spike sample provides information on the extraction efficiency of the method on the sample matrix. Clean sampling techniques will be used to process these samples. One matrix spike blank sample will be processed per sampling event.

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Table 4. Quality assurance sample types and volumes. One of each QA sample type will be collected and analyzed for each sampling event.

Sample Type	DOC (ml)	Total Metals (ml)	Dissolved Metals (ml)
Travel Blank	na	50	na
Field Blank	40	50	50
Field Duplicate	40	50	50
Matrix Spike Blank	na	50	50
Pump tubing Blank	40	50	50

na: not applicable

Chain-of-custody procedures for this project include the following:

- Proper labeling of samples.
- Use of chain-of-custody (COC) forms for all samples.
- Prompt sample delivery to the laboratory.

All aspects of the sample collection process, including generating field logs at each site and chains of custody (COC) forms, will be documented and tracked. COC forms will accompany all water samples to the laboratory for analysis. SCCWRP will retain a copy of all COCs. Physis will document and track all aspects of sample receipt, analyses, and reporting.

Laboratory QA/QC for this project includes the following:

- Use of the lowest available method detection limits (MDLs) for trace elements.
- Analysis of method blanks and laboratory duplicates.
- Use of matrix spikes (to test analytical accuracy) and matrix spike duplicates (to test analytical precision).
- Routine analysis of standard reference materials and method blanks.

Sample Vial and Bottle Labeling

Each sample will have a waterproof paper label affixed to the container and will be labeled at the time of collection. The following information will be recorded on the container label at the time of collection (Figure 3):

- Project name
- Sample identification
- Analysis to be performed
- Laboratory
- Date of sample collection

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Project: MDR SSO
Station: MdRH-E
Analysis: Total Copper
Laboratory: Physis

Figure 3. Sample label example.

7 SAMPLE DELIVERY

Samples will be stored and transported at $4\pm 2^{\circ}\text{C}$. Water samples will be provided to the toxicity and chemistry testing laboratories on the same day that sample collection process is completed. The individual sample containers containing the marine water samples for chemical analysis will be picked up by the analytical chemistry laboratory for analysis. Contacts for the field or laboratory coordinators are shown in Table 5. Each sample must be accompanied by a COC form.

Table 5. Agency contacts.

Coordinator	Agency	Contact Name	Email	Phone
Field	SCCWRP	Dario Diehl	dariod@sccwrp.org	714 755-3212
Toxicity	SCCWRP	Ashley Parks	ashleyp@sccwrp.org	714 755-3216
Chemistry	Physis	Rich Gossett	richgossett@physislabs.com	714 602-5320

8 REFERENCES

USEPA. April 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. EPA 821-R-95-034.

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Field Sampling Forms

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MdR Harbor Water Daily Sampling Log

Date _____ Crew _____

Station _____ Latitude _____ Longitude _____

Time at Start _____ Time at Finish _____

Visual Water Description _____

Picture Numbers _____

pH _____ Salinity _____

Temperature _____ Dissolved Oxygen _____

Other Notes _____

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Date: _____ Project: _____ Experiment(s): _____

pH/DO QA verification sheet

Make the appropriate quality assurance entry for each water quality parameter analyzed. The person performing the analysis for each parameter should write their initials in the space provided. Report QA measurements that do not meet the performance objectives to the QA supervisor for the test.

RPD = $100 \times 2(D1 - D2)/(D1 + D2)$; D1 = measurement 1, D2 = measurement 2

QA Supervisor Approval _____

Performance Objective

pH (YSI Pro1020): Analyst _____

Initial Calibration: Standard solutions no more than four weeks old: _____

Beginning of Run

Reading for freshly obtained lab seawater: _____

7.8-8.2

During Run

Standard (pH 7.0): _____

6.9-7.1

Duplicate pH measurement:

sample type: _____ 1st _____ 2nd _____ RPD _____%

3 %

Were QA objectives met? _____ If not, explain actions taken

Performance Objective

Dissolved Oxygen (YSI Pro1020): Analyst _____

Beginning of run:

Well aerated lab seawater: _____

7.5±0.5

ppm @ 20°C

Duplicate sample measurement:

Sample type: _____ 1st _____ 2nd _____ RPD _____%

8 %

Were QA objectives met? _____ If not, explain actions taken:

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Date: _____ Project: _____ Experiment(s): _____

Salinity QA verification sheet

Make the appropriate quality assurance entry for each water quality parameter analyzed. The person performing the analysis for each parameter should write their initials in the space provided. Report QA measurements that do not meet the performance objectives to the QA supervisor for the test.

$RPD = 100 \times 2(D1 - D2)/(D1 + D2)$; D1 = measurement1, D2 = measurement 2

QA Supervisor Approval _____

**Performance
Objective**

Salinity (YSI Pro30): Analyst _____

Beginning of run:

Lab seawater: cond. _____ temp _____ salinity _____

33 to 35 ppt

During run:

Duplicate conductivity measurement:

Sample type: _____ 1st _____ 2nd _____ RPD _____%

5 %

Standard (Ricca at 25°C): _____

49.9- 50.1 mS

Were QA objectives met? _____ If not, explain actions taken:

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QAPP ATTACHMENT B LABORATORY METHODS

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STANDARD OPERATING PROCEDURES FOR THE DETERMINATION OF DISSOLVED ORGANIC CARBON (DOC) USING THE SHIMADZU TOC-VCPH ANALYZER.

1.0. SCOPE AND APPLICATION

This protocol describes the standard operating procedure for the determination of dissolved organic carbon (DOC) in freshwater or seawater using the Shimadzu TOC-VCPH analyzer.

2.0. SUMMARY OF METHOD

Samples are loaded into the ASI autosampler and programmed for automatic run. For the DOC analysis, the instrument injects the sample into the TC combustion tube, which is filled with an oxidation catalyst and heated to 680 °C. The sample is converted to CO₂ and analyzed by a non-dispersive infrared (NDIR) gas analyzer after passing through a dehumidifier and halogen scrubber (remove Cl). The NDIR outputs an analog detection signal that forms a peak that is proportional to the DOC concentration of the sample.

3.0. INTERFERENCE

- 3.1. All glassware should be washed with soap and water, rinsed with water and de-ionized water, and kilned at 1000 °F for one hour.
- 3.2. All working surfaces and equipment should be clean and free of particles and organic solvents, which will increase carbon levels in the samples. Use aluminum foil on all working surfaces.
- 3.3. Remove all organic solvents from area of sample preparation and limit exposure of sample to air to eliminate possibility of solvent vapors and CO₂ contamination of sample.
 - 3.3.1. CO₂ in atmosphere ranges from 300 – 500 mg/L. Dissolved amounts ~0.2 mg/L depending on temperature and CO₂ in atmosphere.
- 3.4. If seawater is analyzed, limit sample number to <50 samples (calib. and controls included) per run to prevent overloading combustion column catalyst with salts, which will decrease analysis reproducibility. Wash or replace catalyst if sensitivity and reproducibility become a problem.
 - 3.4.1. Thoroughly wash the catalyst with tap water while in the column to remove accumulated salts.

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- 3.4.2. Neutralize alkalis with hydrochloric acid diluted to about 5:1.
- 3.4.3. Rinse the catalyst with tap water to remove the acid.
- 3.4.4. Rinse with D I water and dry at 100 °C for 8 hrs.

4.0. APPARATUS AND MATERIALS

4.1. Apparatus

- 4.1.1. Shimadzu TOC-VCPH/CPN w/ auto-sampler (fig 1)
- 4.1.2. TOC-Control V software, PC w/ Windows 95 or later.
- 4.1.3. 25 mm GF/F filters w/ filtering apparatus.
- 4.1.4. Vacuum pump.
- 4.1.5. 125 ml boiling flask or DO bottles.
- 4.1.6. Halogen scrubber (part no. 630-00992)
- 4.1.7. Parafilm.
- 4.1.8. Combustion tube (part no. 638-41323).
- 4.1.9. Ceramic fibers (part no. 638-60074).
- 4.1.10. TOC regular catalyst (part no. 638-92069-01).

4.2. Glassware.

- 4.2.1. 40 ml I-Chem glass vials w/ caps.
- 4.2.2. 1000 ml volumetric flask.
- 4.2.3. 100 ml volumetric flask.

4.3. Gas Supply

- 4.3.1. Compressed air ultra-zero.

4.4. Reagents

- 4.4.1. Concentrated HCl.
- 4.4.2. Milli-Q water
- 4.4.3. Potassium hydrogen phthalate (KHP) reagent grade.
- 4.4.4. Sodium bicarbonate reagent grade.
- 4.4.5. Sodium carbonate reagent grade.
- 4.4.6. Potassium nitrate reagent grade.

5.0. SAMPLE HANDLING AND PRESERVATION

5.1. Sample Handling.

- 5.1.1. A chain of custody should be maintained. As samples are received they are checked for damage and logged into the laboratory sample ID file.

5.2. Sample Storage.

- 5.2.1. Store aqueous samples in clean kilned glass jars.
- 5.2.2. Store samples in a refrigerator at 4 °C until analyzed.

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- 5.2.3. Holding time of 28 days after acidification/filtration should be observed.
- 5.2.4. High conc. standard stock solution (1000 ppm) can be stored for about 2 months in an air tight glass flask at 4 °C while diluted standard solutions can be stored for only 1 week.

6.0. PROCEDURE

- 6.1. Sample Processing.
 - 6.1.1. Filter water samples through GF/F filter before analysis to remove organic particulates.
 - 6.1.2. Collect enough filtrate to fill a 125 ml boiling flask and cap leaving no head space.
 - 6.1.3. Acidify sample with concentrated HCl to pH-2. At this point samples can be stored for a short period of time 1-2 days.
 - 6.1.4. Pour acidified sample into a 40 ml sampling vial (minimize headspace) and cover with parafilm.
 - 6.1.5. Load samples on instrument carousel.
 - 6.2. Prepare TC Standard Stock Solution
 - 6.2.1. Accurately weigh 2.125 g of reagent grade potassium hydrogen phthalate (KHP) that was previously dried at 105-120 °C for 1 hr and cooled in a desiccator.
 - 6.2.2. Transfer KHP to a 1 L volumetric flask and add Milli-Q water to the 1 L mark. Mix the solution. Carbon conc. of the solution is 1000 mg C/L (1000 ppm C)
 - 6.2.3. Prepare 5 calibration concentrations from TC standard stock solution. Calibration point concentrations will change depending on sample range but for most seawater samples the calibration concentrations will be as follows.
 - Calibration pt. 1 – 0 ppm C
 - Calibration pt. 2 – 0.5 ppm C
 - Calibration pt. 3 – 1.0 ppm C
 - Calibration pt. 4 – 2.5 ppm C
 - Calibration pt. 5 – 5.0 ppm C
 - Calibration pt. 6 – 10.0 ppm C
- Calibration preparation:
- 1000 ppm stock C.
 - 100 ml vol.
 - 0.5 ppm C – 50 µl 1000 ppm C
 - 1.0 ppm C – 100 µl 1000 ppm C

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2.5 ppm C – 250 µl 1000 ppm C
 5.0 ppm C – 500 µl 1000 ppm C
 10.0 ppm C – 1000 µl 1000 ppm C
 dilute to 100 ml with milli-Q water.

6.2.4. Prepare QA/QC controls.

0 ppm C (milli-Q water)
 1.0 ppm IC/OC
 5.0 ppm C

6.2.4.1. Prepare a sparge control solution of 1.0 ppm organic C / 1.0 ppm inorganic C and treat as an unknown sample (acidify and sparge).

1.0 ppm IC/OC – 100 µl 1000 ppm C and 100 µl 1000 ppm IC
 diluted to 100 ml with milli-Q water. Add conc. HCl to pH 2.

6.3. Prepare IC Standard Stock Solution.

6.3.1. Accurately weigh 3.50 g of reagent grade sodium hydrogen carbonate that was previously dried for 2 hrs in a silica gel desiccator, and 4.41 g of sodium carbonate previously dried for 1 hr at 280-290 °C and cooled in a desiccator.

6.3.2. Transfer the weighed materials to a 1L volumetric flask and add zero water to the 1L mark. Mix the solution. Conc. of this solution is 1000 mg C/L (1000 ppm C) inorganic carbon.

6.3.3. Use this stock solution for the inorganic carbon fraction of the sparge control solution.

6.4. Load calibration, controls and sample vials on ASI-V turntable.

6.5 Turn power on main instrument.

6.6 If TN analysis is performed, turn power on the TN unit and ozone generator.

6.7. Adjust instrument carrier gas pressure to 200 kpa.

Adjust the flow rate to 150 ml/min.

6.8. Adjust ozone source airflow knob on the TN unit to 500 ml/min.

6.9 Start TOC Control V software and select sample table editor and enter user name (System) and password (TOC6001).

6.9.1. If sample table have already been created, open it from the file menu.

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- 6.9.2. Establish communication between software and the instrument by selecting [connect] from the instrument menu.
- 6.10 If sample table has not been created, continue with sample table setup and establish communication between the software and the instrument when table is completed.
- 6.11 Create a calibration file.
 - 6.11.1 Select [New] [Calibration curve] in file menu. Currently using npoccal06.
 - 6.11.2 Select the following in the calibration curve options.
 - 6.11.2.1 System – TC/TN for DOC or TN analysis.
 - 6.11.2.2 Calibration curve type – Edit calibration points manually.
 - 6.11.2.3 Analysis information – TC (enter sample name and sample ID)
 - 6.11.2.4 File name - Enter calibration file name.
 - 6.11.2.5 Units – ppm.
 - 6.11.2.6 No. washes – 2
 - 6.11.2.7 Enter calibration points info.
 - 6.11.2.8 Repeat with TN calibration.
 - 6.11.3 Enter the calibration standard runs in the sample table.
 - 6.11.4. Place cursor in the first row of the sample table.
 - 6.11.5. Select [calibration curve] in the insert menu.
 - 6.11.6. Specify calibration file used for the analysis and click open.
 - 6.11.7. Enter vial positions in the sparge/acid addition window.
- 6.12. Create a method file for unknown samples.
 - 6.12.1 Select [New] [Method] in file menu.
 - 6.12.2 Select the following in the method options. Currently using NPOCmethod07.
 - 6.12.2.1 Analysis information – TC/TN (enter sample name and sample ID)

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- 6.12.2.2 File name - Enter method file name.
- 6.12.2.3 Calibration curve 1 – Enter calibration file used.
- 6.13 Enter the unknown samples in the sample table.
 - 6.13.1. Place cursor in the row following the calibration curve entry in the sample table.
 - 6.13.2. Select [sample], in the insert menu
 - 6.13.3. Specify calibration file and method file used for the analysis.
 - 6.13.4. Enter sampling parameters. Always include 5 minutes of sparging.
 - 6.13.5 Enter vial positions in the sparge/acid addition window.
 - 6.13.6. Save sample table by selecting [save] from the file menu.
- 6.14 Check status of the instrument detectors before starting analysis. Temperature should read 680 °C (720 °C if TN analysed) in background monitor.
 - 6.14.1 Fill ASI auto-sampler rinse bottle (see 1, fig 1) with zero water.
 - 6.14.2 Check humidifier (see 1, fig 2) water level and fill if needed.
 - 6.14.3 Flush lines to TC furnace and auto-sampler by performing line wash in maintenance.
 - 6.14.4 Perform auto regeneration of IC solution in maintenance if level is low or nearly empty.
 - 6.14.5 Check Halogen scrubber (see 3, fig 2) for discoloration of absorbent inside casing as it absorbs chlorine. Replace if discoloration band reaches ~2 cm from end of scrubber.
- 6.15 Start run.
 - 6.16.1 In the instrument menu select [start]
 - 6.16.2 Verify the vial positions when the sparge/acid addition window appears and click OK.
 - 6.16.2 Start ASI measurement.
 - 6.16.3 Check status of measurements by selecting [sample window] in the view menu. A graph display will appear for the current injection.

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6.16.4 If analysis locks up (occurs with insufficient memory on computer) select, stop halt analysis, highlight the last sample analyzed and select [delete data] in the edit menu. Restart the analysis by selecting [start (continue)] in the instrument menu. Be sure to type in the vial location of the sample (deleted data) in the vial position window that appears before analysis begins. The program will begin analysis from the next sample after the last successful analysis.

6.16 End measurement.

6.16.1. Select standby in the instrument menu [shut down instrument]. A 30 min countdown to instrument shutdown begins.

7.0. Quality Assurance/ Quality Control

7.1. Sample blank

7.1.1. A zero C water blank is processed for every batch of 12 samples. Currently using template control06_0C.

7.2 Control samples.

7.2.1. One 5.0 ppm C is processed for every 12 samples. Currently using template control06_5C for carbon.

7.3 Sparge control.

7.3.1. One set of an acidified and sparged mixture of 1.0 ppm KHP solution is processed for every 12 samples. Currently using template cont06_1ppm for carbon.

7.4 Sample replicate.

7.4.1. One or more replicate samples is processed for each batch of 12 samples.

8.0. Safety

8.1. Analyst should wear safety glasses and gloves during all procedures to prevent sample and chemical contact with the skin and eyes.

8.2. Analyst should be careful not to touch hot connections near combustion columns.

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- 8.3. Analyst should read MSDS for all the chemicals and reagents used and follow all safety recommendations in the MSDS.



Fig. 1



Fig. 2

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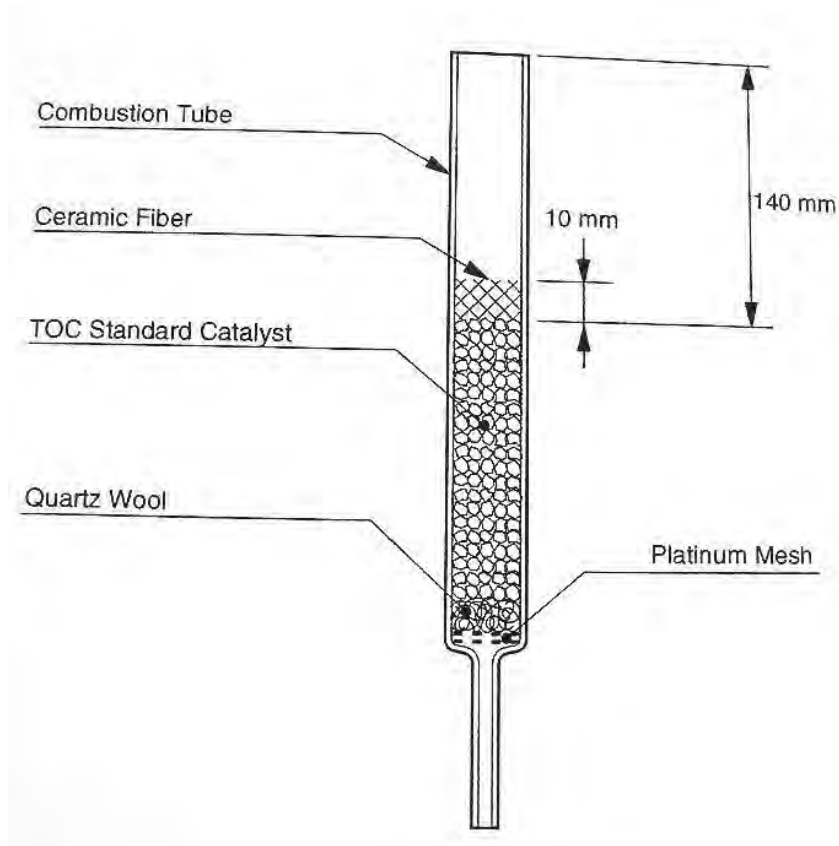


Fig. 3

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Southern California Coastal Water Research Project Toxicology Laboratory Standard Operating Procedure for Mussel Embryo Development Test

I. Overview

This method estimates the toxicity in aqueous samples by a 48 hour exposure of *Mytilus galloprovincialis* embryos. The test endpoint is normal embryo development and survival. The test is based on methods in the EPA's Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms (EPA/600/R-95/136). The purpose of this SOP is to detail the test procedure as specifically applied in our laboratory. The SOP is intended to supplement the material in the protocol, not replace it.

II. Supply Checklist

- Deep trays for use as water baths (2)
- Glass bread pan (2)
- Seawater and DIW squirt bottles
- pH, DO and conductivity meter/probes
- Graduated cylinders 50-1000 ml for making gamete and solution dilutions
- Automatic pipets 0.1 ml up to 10 ml
- Water pump
- Tubing
- Thermometer
- 250 ml, 400 ml and 1 L beakers (several)
- Inverted microscope
- Counter, 2 unit
- Sedgwick-Rafter counting chamber
- Perforated plunger to fit 250 ml, 400 ml and 1 L beakers
- Nitex screening 100 µm or smaller openings
- Razor blades
- Eppendorf Pipet tips (100 µl, 1 ml and 10 ml)
- Shell vials with translucent caps, 5 dram
- Formalin, 30% borax buffered (see recipe below)
- Dispenser for formalin to repeatedly deliver 1 ml
- Pasteur pipets and bulbs (both 5 ¾ and 9 in)
- Scintillation vial racks (plastic for exposure, cardboard for storage)
- Spawning and gamete calculation data sheet
- Glass or Fiberglass aquaria tanks (3)
- Air pump
- Pairing knife.
- Air stones
- UV Light –to pass seawater through

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III. Animals Collection and Culturing

Adult Bivalves (*Mytilus galloprovincialis*) are obtained from a commercial supplier. Set up glass aquaria in the cold room. To each tank add about six inches of seawater the day before the mussels arrive. Temperature shock may cause the animals to spawn; therefore once you have received the mussels, the animals should be acclimated to the cold room by opening the travel cooler. After about two hours of acclimation, transfer the mussels equally among the tanks, and add air stones.

The seawater should be changed everyday. Mussels can remain in holding under optimal conditions up to eight weeks from receiving date. No food is given to the mussels while in holding. Water quality measurements (pH, ammonia, DO and salinity) should be made on the system on a weekly basis.

IV. Test Design

Summary of test conditions

Type: Static non-renewal

Salinity: 32 ± 2 g/kg

Temperature: 15 ± 1 °C

Duration: 48 hours

Endpoint: normality of development and survival

Exposure volume: 10 ml

Test containers: 29.35 x 55 mm (5 dram) glass shell vial with snap cap.

Lighting: Ambient laboratory

Photoperiod: 16 hours Light and 8 hours Dark

Salinity adjustment: Hypersaline brine

Dilution water: natural seawater (activated carbon and 0.45 µm filtered)

Water Quality: DO, pH, salinity and ammonia (optional)

Reference toxicant: concurrent with each experimental batch, ammonia chloride or copper chloride

Exposures should be conducted in 5 dram glass shell vials. The vials should be vigorously rinsed with DIW and allowed to dry before use. Vials should be labeled and randomly distributed in vials racks (based on our experiment set-up randomization program).

The sample volume is 10 ml per replicate, with 4 replicates per concentration. Include an additional 5 vials of 32 ‰ seawater to determine the actual embryo density. After the samples are in the vials, the vials should be placed in the 15 °C room for at least ½ hr before starting the exposure. The vials should be kept covered with parafilm whenever possible from the time of labeling through the end of the exposure to prevent cross contamination and evaporation.

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V. Sample Handling

Care should be taken during sample preparation and dilution that cross contamination of glassware used for the samples and for the gametes does not occur. The exposure vials should be covered at all times to prevent contamination.

Samples having a salinity of less than 30 ‰ should be adjusted using hypersaline brine. To make the brine, first place a glass container (usually a 1 L beaker or 1 Gal jar) of seawater in a freezer for at least 18 hr. Remove the container from the freezer and allow the ice to thaw at room temperature. During the thawing process, occasionally pour off the thawed brine to a clean beaker. When the salinity of the brine is close to the desired level, or the volume needed is achieved, final dilution of the brine to the desired level should be made using seawater. The salinity of the brine used for sample adjustment should never exceed 80 ppt, as higher levels have been known to cause toxicity. When testing samples that have no saline content (stormwater, sewage effluent, etc) it is usually desirable to make the brine at 64 ‰ so that a 50:50 mixture of sample and brine has a final salinity of 32 ‰. We have found that brine may be stored in the refrigerator for up to a week.

Water quality measurements are made at the beginning and end of the testing time. Separate sub-samples for water quality analysis of each test sample or dilution should be taken at the time the samples are prepared. Samples should be measured for pH, DO and salinity. Ammonia analysis should be considered optional.

VI. Reference Toxicant

Each test of field or laboratory samples should include a concurrent reference toxicant exposure to ammonia. Copper can be used as an alternative reference toxicant. The reference toxicant exposure should include a control (0 µg/L) and five concentrations of ammonia.

The ammonia concentrations are prepared with ammonium chloride. The ammonia concentrations tested should be 0, 2.0, 4.0, 6.0, 8.0 and 10.0 mg/L. First prepare a stock solution of 1000 mg/L ammonia with 0.297g of NH₄Cl and 100 mL DIW. Then use the stock solution to achieve these concentrations by adding 0.2, 0.4, 0.6, 0.8, and 1.0 mL of stock solution to seawater to make 100 ml of each concentration. An ammonia sample will also be measured from each concentration on day 0 in order to calculate the actual total and unionized ammonia concentrations. An extra vial for each concentration should be included at test initiation for water quality analysis at test termination.

The copper reference toxicant concentrations are prepared by first making a stock solution of 10,000 µg/L copper. This stock solution consists of 0.0268 g CuCl₂·2·H₂O in 1 L DIW. A working stock is prepared by diluting 10 ml of stock solution into 90 ml of seawater to produce a concentration of 1,000 µg/L. These concentrations are achieved by adding 0.45, 0.65, 0.95, 1.39, 2.04, and 3.00 mL of working stock to seawater to make 100 ml of each concentration. An

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approximately 40 ml sample of the highest concentration should be saved in a plastic container for copper concentration verification. This sample should be preserved by adding two drops of concentrated, redistilled nitric acid then storing it in the refrigerator.

VII. Test Procedure

A. Before Spawning Mussels

Fill about half full with 32‰ seawater two deep trays and heat with an aquarium heater to 20 °C. Place both bread pans and the pump with tubing in one of the trays. With seawater, rinse about fifteen 250 ml beakers and fill with 75 mL of seawater at 15 °C.

Gently scrap off the barnacles and other encrusting organisms with a pairing knife from twenty mussels. Then rinse animals with 32 ‰ seawater.

B. Mussel Spawning

Place the animals into bread pans in the 20 °C seawater bath. Turn on the water pump so that there is flow in each pan. Note initial time of mussel addition, look for spawning mussels, after 30 min. stop the pump. Wait 15 min. If no spawning occurs place the mussels in a 15 °C, 32 ‰ seawater bath for 15 min. then start the process again. At least two animals of each sex with good gamete quantity and quality are necessary.

C. Gamete Collection

When individual animals are observed shedding gametes, remove them from the pan. Rinse each animal individually thoroughly with 32 ‰ seawater and place in their own 250 mL beaker that has enough seawater to cover the animal at 15 °C.

Early in the spawning process, using a clean Pasteur pipet mix up the eggs in the beaker from one female and transfer about 0.5 ml of egg solution to the rafter cell. Check the eggs on the microscope at 100X power. Greater than 90% of the eggs should be round, of average size, not clumped, and not containing germinal vesicles. If the eggs appear to be of good quality, add a very small amount of sperm to the eggs in the Rafter cell. Watch for motility of the sperm and the ability to fertilize. Continue checking so that all of the males and females are tested in this manner.

D. Egg Counting

Allow the eggs of the females that were deemed to be in good condition to settle to the bottom of their collection beakers. Pour off most of the water from each beaker, then pour the remaining water with the eggs through the 100 um nitex screen into a 1 L beaker. After adding the eggs from all the “good” females, bring the water level in the beaker up to about 600 ml. Allow the eggs to resettle (about ½ hr. After the eggs have settled, again pour off most of the water, then again pour the eggs through the nitex into a clean 1 L beaker. Again bring the water up to about 600 ml.

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Put 9 ml of seawater into each of two scintillation vials, labeled A and B. Using the perforated plunger mix the egg solution well and take a 1 ml sample and place it into vial A. Mix vial A well and take 1 ml sample from it and place in vial B. Mix vial B well and place a 1 ml sample onto the Rafter cell. Count all of the eggs on the Rafter cell on a microscope a 100X. If total count is less than 30, then use vial A for counting. Record the count in the appropriate place on the egg and sperm count form. Take a second sample from vial B and count. Record the second count. If the two counts are within 20% calculate the mean. If the counts are not within 20%, count one more sample before calculating the mean. The egg density target should be about 5000-8000 eggs/ml. This is a stock solution, so if the egg density is higher or lower it is ok; just use the actual value when calculating the embryo density. Density must not be less than 1500. If the density of the eggs is less than 1500, let the eggs settle and decant excess water. Recount the eggs as described above.

E. Sperm suspension

Filter high quality sperm through a 100 um nitex screen into one beaker and make a note as to which animals were used on the mussel spawning data sheet.

F. Trial fertilization test

A trial fertilization must be performed with each spawning event. A series of sperm dilutions will be performed to achieve final sperm to egg ratio. Use a 10 mL pipet with the tip cut off to place 10 mL of egg suspension into three scintillation vials. Add 0.1, 0.3, and 1.0 mL of sperm suspension using pipets. Let these solutions sit for 1.5 –2.5 hours in the lab. Transfer about 0.5 ml of egg solution to the rafter cell. Check the eggs on the microscope at 100X power. Fertilized eggs will have a single polar body, a very small clear circle attached to an egg, or they will have multiple cells that look like Mickey Mouse ears. Use the ratio of egg to sperm that has the lowest amount of sperm to achieve >90% fertilization.

While the eggs are being fertilized, finish the egg counts and determine the eggs/mL concentration. (See Mussel Spawning Datasheet)

To calculate the sperm suspension volume necessary to add to the egg solution, take the volume of the egg suspension prepared in section D and multiply by the sperm to egg ratio determined in the trial fertilization.

G. Test Initiation

Add sperm to eggs (embryo suspension), and use the perforated plunger to mix the suspension. Adjust the embryo suspension density to 1500 – 3000/ ml. Our target density and volume for the embryo suspension is 2500 embryos/mL in 300mL of 32 ‰ seawater. (See Mussel Spawning Datasheet) Achieve this by measuring out the needed amount of embryo stock solution and add 15 °C seawater to a total value of 300mL. Use the perforated plunger to mix the suspension. Cover the beaker with parafilm and set aside until ready to use (do not let stand for more than one hour).

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On the mussel spawning record form record the time that you will add the embryo solution to the first vial. Using the perforated plunger, continually agitate the embryo solution while adding 0.1 ml to each exposure container. Be careful to ensure that the embryo solution is added to the liquid in the exposure containers and does not contact the side of the vials first. Record the time that you finish the embryo addition. Recover the vials with the parafilm. Record the temperature at which the exposure is being performed.

The 5 additional vials of seawater will serve as the initial embryo density sub-samples. One mL of 30% borax buffered formalin will be added to each vial within minutes of the embryo solution addition. These will be used to determine the survival in the controls and the other treatments. Record the counts on the embryo count form. Calculate the actual embryo density by averaging the 5 sub-samples.

48 hours after the start of the addition of embryos, transfer the racks of exposure vials to the Biology Lab. Terminate the test by adding 1 ml of 30% borax buffered formalin to each vial. This should be done inside a fume hood. The formalin should be dispensed from the re-pipettor. Secure a snap cap on each vial and give the vial a quick swirl to ensure that the formalin is evenly distributed. This task is made easier with two people; one adding the formalin and the other capping and swirling the vials.

VIII. Microscopic Evaluation

The samples can be evaluated whenever convenient. There is not a known maximum holding time for preserved samples.

The samples are evaluated by placing the entire vial in a small petri dish and placing this over the objective port on the stage of the inverted microscope. The embryos are easily viewed at 100 X. Start at the top of the vial and move across to the opposite side, scoring all "D" shape embryos as normal and those without the "D" shape as abnormal. Move the stage down one field of view and make another complete pass of the vial; continue this process until the entire vial has been counted. Record the results on the mussel embryo development examination data sheet and put a colored dot on the cap to designate it as counted.

IX. Data Analysis

There are three endpoints that can be analyzed. One endpoint is the percent normal. In this case the number of normal embryos is divided by the total number of normal and abnormal embryo present in a vial then multiplied by 100. A second endpoint is percent normal alive, which is the number of normal embryos present in the vial divided by the mean of the initial count multiplied by 100. The third endpoint is percent alive. In figuring the percent alive one assumes that if embryos are present, no matter what condition, then they are alive. To

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calculate percent alive sum of both the normal and the abnormal embryos and divide by the mean of the initial count of embryos multiplied by 100.

Enter the endpoint data into the Excel spreadsheet by container number. The means and standard deviations are calculated automatically by the spreadsheet. For each experiment, run an ANOVA and Dunnett's test using Toxstat. Use a point estimation program (such as Toxstat) to calculate the EC50 using the probit method.

The reference toxicant data are similarly entered in the appropriate Excel spreadsheet. Calculate the EC50 as above and plot this value on the running laboratory control chart for this bioassay.

X. Quality Assurance

Test Acceptability Criteria

Mean normal development in the controls must be at least 90%. Mean survival in the controls must be > 50%. The percent minimum significant difference (MSD) must be less than 25%.

Reference toxicant results

The reference toxicant EC50 should fall within two standard deviations of the mean on the control chart. If the EC50 falls outside this range, results of concurrent tests should be examined carefully. The investigator should include a discussion of the significance of the exceedance in any report of the data.

Deviations from test conditions

Deviations from acceptable test conditions must be recorded (i.e. temperature out of range). Best professional judgment will be applied to determine whether the deviation was significant enough to render the results of the test questionable. The investigator should include a discussion of the significance of the deviation in any report of the data.

XI. Cleaning procedures

The exposure vials are used as shipped except that they should be vigorously rinsed with DIW and allowed to dry before use. All glassware and plastic ware used in handling the gametes or samples should be processed under the normal toxicology lab cleaning procedure to remove metals and organics.

After it is decided that the embryo samples can be discarded, the vials should be emptied into the sink under a fume hood with running water. The vials should then be rinsed once with tap

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water and then discarded in the trash. To prevent injuries from broken glass, it best to accumulate the discarded vials in a separate trash bag and then discard directly to the dumpster.

XII. References

USEPA, 1995. "Short-term methods of estimating the chronic toxicity of effluents and receiving water to west coast marine and estuarine organisms. National Exposure Research Laboratory, Office of Research and Development. Cincinnati, Ohio.

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Mussel Spawning Data Sheet

Experiment No. _____ Animal Source _____
 Date _____ Time in Culture _____
 Temperature of Water Bath _____

Mussel No.	Induction	Spawn	Sex	Comments
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

Pooled eggs from mussels _____
 Pooled sperm from mussels _____

Egg Counts

Sample	Dilution	Count	Eggs/mL

For 300 mL of embryo suspension at 2500 embryos/mL use:
 $300 \times 2500 / (\text{counted eggs/mL}) = \text{mL of egg stock}$



STANDARD OPERATING PROCEDURE

for EPA Method 1640

**DETERMINATION OF TRACE ELEMENTS IN SALINE WATER BY PRECONCENTRATION
AND INDUCTIVELY COUPLED PLASMA - MASS SPECTROMETRY**

REVISION # 1 Effective date: June 15, 2010

Approved by:

Name	Title	Phone	Signatures	Date
Misty Mercier	Laboratory Director			
Rhonda Moeller	Quality Manager			

METHOD 1640:

EXTRACTION OF TRACE METALS IN SEAWATER AND SEDIMENT

REFERENCES: Battelle Pacific Northwest Laboratories, Marine Sciences Laboratory. Standard Operating Procedure MSL-M-034-01. APDC Extraction of Metals in Seawater.

Bloom, N.S. and Crecelius, B.A. 1984. Determination of Silver in Seawater by Coprecipitation with Cobalt Pyrrolidine Dithiocarbamate and Zeeman Graphite-Furnace Atomic Absorption Spectrometry, *Analytica Chimica Acta*, 156, pp.139-145.

Danielsson, L., Magnusson, B., and Westerlund, S. 1978. An Improved Metal Extraction Procedure for the Determination of Trace Metals in Sea Water by Atomic Absorption Spectrometry with Electrothermal Atomization, *Analytica Chimica Acta*, 98, pp. 47-57.

Jan, T.K. and Young, D.R. 1978. Determination of Microgram Amounts of Some Transition Metals In Seawater by Methyl Isobutyl Ketone-Nitric Acid Successive Extraction and Flameless Atomic Absorption Spectrophotometry. *Analytical Chemistry*, 50, No. 9, pp. 1250-1253.

U.S. Environmental Protection Agency, Office of Water Engineering and Analysis Division (4303): Method 1640.

EPA Methods for Chemical Analysis of Water and Wastes, Method 200.8, Revision 5.4 (May, 1994); NOAA Sampling and Analytical Methods of the National Status and Trends Program, Volume III, (1993)

1.0 SCOPE AND APPLICATION

- 1.1 This method provides procedures for the extraction and preconcentration of dissolved and particulate elements from aqueous samples using chelation and precipitation for subsequent analysis by inductively coupled plasma mass spectrometry (ICP-MS). It includes stringent quality control (QC) and sample handling guidelines necessary to avoid contamination and ensure the validity of analytical results

during sampling and analysis. The method contains QC procedures that will ensure that any possible contamination will be detected when blanks accompanying samples are analyzed.

Table 1.

ANALYTE	SYMBOL	AMU	CASRN
Aluminum	(Al)	27	7429-90-5
Antimony	(Sb)	123	7440-36-0
Arsenic	(As)	75	7440-38-2
Beryllium	(Be)	9	744-38-2
Cadmium	(Cd)	111	7440-43-9
Chromium-total	(Cr)	52	7440-47-3
Cobalt	(Co)	59	7440-48-4
Copper	(Cu)	63	7440-50-8
Iron	(Fe)	56 or 57	7439-89-6
Lead	(Pb)	206, 207, or 208	7439-92-1
Manganese	(Mn)	55	7439-96-5
Mercury	(Hg)	202	7439-97-6
Molybdenum	(Mo)	98	7439-98-7
Nickel	(Ni)	60	7440-02-0
Selenium	(Se)	82	7782-49-2
Silver	(Ag)	107	7440-22-4
Thallium	(Tl)	205	7440-28-0
Tin	(Sn)	118	7440-31-5
Titanium	(Ti)	48	
Vanadium	(V)	51	7440-62-2
Zinc	(Zn)	66	7440-66-6

Table 1. Target analytes in seawater samples extracted from both the APDC and iron-palladium procedures. The CASRN is the Chemical Abstract Services Registry Number.

Table 2.

PARAMETER	METHOD DETECTION LIMIT (ug/L)	ACCEPTANCE RANGE (%)	REPORTING LIMIT (ug/L)
Aluminum (Al)	0.01	52-149	0.025
Antimony (Sb)	0.01	44-97	0.025
Arsenic (As)	0.01	71-112	0.025
Barium (Ba)	0.5	70-130	1

Beryllium (Be)	0.005	62-113	0.01
Boron (B)	0.5	70-130	1
Cadmium (Cd)	0.005	69-100	0.01
Calcium (Ca)	0.5	70-130	2
Chromium (Cr)	0.005	85-133	0.01
Cobalt (Co)	0.005	75-124	0.01
Copper (Cu)	0.005	72-108	0.01
Iodine (I)	0.5	70-130	1
Iron (Fe)	0.01	35-97	0.025
Lead (Pb)	0.005	56-116	0.01
Lithium (Li)	0.01	70-130	
Magnesium (Mg)	5	70-130	10
Manganese (Mn)	0.005	64-120	0.01
Mercury (Hg)	0.005	68-117	0.01
Molybdenum (Mo)	0.005	59-125	0.01
Nickel (Ni)	0.005	68-118	0.01
Potassium (K)	5	70-130	10
Selenium (Se)	0.01	55-110	0.025
Silver (Ag)	0.005	66-125	0.01
Sodium (Na)	5	70-130	10
Strontium (Sr)	0.01	70-130	0.025
Thallium (Tl)	0.005	66-92	0.01
Tin (Sn)	0.005	68-110	0.01
Titanium (Ti)	0.005	95-143	0.01
Vanadium (V)	0.005	95-140	0.01
Zinc (Zn)	0.005	62-108	0.01

Table 2. The Approximate detection limits, acceptance range, and reporting limits for the target analytes in aqueous samples.

2.0 SUMMARY OF METHODS

- 2.1 An aliquot of a well-mixed, homogeneous sample is accurately measured for sample processing. Target metals are chelated out of the aqueous sample using ammonium pyrrolidine dithiocarbamate (APDC). The chelated precipitate is filtered onto a membrane filter and then digested in a nitric acid solution.
- 2.2 An aliquot of a well-mixed, homogeneous seawater sample is accurately measured for sample processing. Target metals are co-precipitated out of the sample using borohydride Iron-Palladium reductive precipitation. The precipitate is centrifuged out of the seawater matrix. The metal-containing pellet is then digested with nitric acid.

- 2.3 An aliquot of sample is diluted from 10-100 times before it is acidified using HNO₃ until the pH is <2. The diluted, acidified sample must sit for a minimum of 16 hours before it can be analyzed.
- 2.4 The sample is then analyzed using Inductively Coupled Plasma Mass Spectrometry (ICPMS) by pumping the sample through a nebulizer producing a fine spray. An argon carrier gas atomizes the sample which is ionized and detected with a mass spectrometer. Qualitative identification is based on the mass to charge ratio for each element. It is recommended that samples be analyzed within 1 day of digestion.

3.0 PREVENTION OF INTERFERENCE

- 3.1 Samples may be contaminated by numerous routes. Contamination by trace metals can occur due to the use of metallic or metal-containing labware (e.g., talc gloves which contain high levels of zinc), containers, sampling equipment, reagents, and reagent water during sampling. Contamination also results from improperly cleaned and stored equipment, labware, and reagents, as well as from atmospheric inputs such as dirt and dust.
- 3.2 The avoidance of contamination can be achieved by carrying out the following procedures:
 - 3.2.1 Clean sample containers, nucleopore filters, and filtration apparatus with acid and rinse with Milli-Q water. Upon cleaning, store the labware in clean zip-type bags and place them in a plastic box.
 - 3.2.2 Keep samples and glassware covered when possible.
 - 3.2.3 Ensure all materials that come into contact with the sample are nonmetallic. Only the following materials should come into contact with samples: fluoropolymer (FEP, PTFE), conventional or linear polyethylene, polycarbonate, polypropylene, polysulfone, or ultrapure quartz. All materials that will directly or indirectly contact the sample must be cleaned or must be known to be clean and metal free before proceeding.
 - 3.2.4 Minimize exposure of sample to an uncontrolled atmosphere.
- 3.3 ICPMS Interferences
 - 3.3.1 Chemical interferences are characterized by molecular compound formation, ionization effects and solute vaporization effects. These

effects are not usually pronounced with the ICPMS technique due to the high temperature of the torch.

3.3.2 Isobaric interferences are caused by isotopes of different elements which form singly or doubly charged ions of the same nominal mass-to-charge ratio and which cannot be resolved by the mass spectrometer. All elements determined by this method have one isotope free of isobaric elemental interference except Selenium-82, which has isobaric interference from the Krypton impurities in the Argon gas supply. This interference can be minimized by using high purity argon. All data must be corrected by measuring the signal from another isotope of the interfering element and subtracting the appropriate signal ratio from the isotope of interest.

3.3.3 Wing overlap interferences may occur when a small ion peak is being measured adjacent to a large one. The potential for these interferences should be recognized and the spectrometer resolution adjusted to minimize them.

3.3.4 Polyatomic interferences are caused by ions consisting of more than one atom which have the same nominal mass-to-charge ratio as the isotope of interest, and which cannot be resolved by the mass spectrometer. The ions may be formed in the plasma or interface system from support gases or sample components. Most of the common interferences have been identified and are listed within the instrument data system along with the elements affected. All data shall be corrected by measuring the signal from another isotope of the interfering element and subtracting the appropriate signal ratio from the isotope of interest. Equations for the correction of the data are presented below in Table 3.

Table 3.

ELEMENT	MASS	EQUATION
Vanadium	51	$(51)*1 - (53)*3.127 + (52)*0.353$
Arsenic	75	$(75)*1 - (77)*3.132 + (82)*2.736 - (83)*2.761$
Selenium	82	$(82)*1 - (83)*1.0087$
Molybdenum	98	$(98)*1 - (99)*.0146$
Cadmium	111	$(111)*1 - (108)*1.073 + (106)*0.764$

3.3.5 Physical interferences are effects associated with the sample nebulization and transport processes. Properties such as the change in viscosity and surface tension can cause significant inaccuracies, especially in samples that may contain high dissolved solids and/or acid concentrations. These interferences are greatly

reduced in this procedure by the use of mass flow controllers for the control of the argon flow rate, the use of a peristaltic pump for sample introduction, and the use of internal standards.

4.0 SAFETY

- 4.1 It is mandatory to wear a laboratory coat, closed-toe shoes, and safety glasses in the Laboratory. Gloves shall be worn while working with samples and acids.
- 4.2 All steps involving the use of concentrated acids shall be performed in a fume hood.
- 4.3 Material Safety Data Sheets (MSDS) are on file and available at all times to personnel using hazardous materials. It is the responsibility of everyone using these materials to be familiar with the potential hazards to the chemicals in their work area. If the analyst is uncertain of the potential hazards of specific chemicals, contact a supervisor prior to using these chemicals.
- 4.4 Extreme caution, awareness and knowledge of the location and safe use of fire extinguishers, eye wash fountains, and safety showers are required.
- 4.5 Personnel performing this procedure shall be instructed in the safe use of acids, the requirements for protective equipment, and acid spill cleanup procedures.

5.0 APPARATUS AND MATERIALS

- 5.1 APDC procedure
 - 5.1.1 250 ml polyethylene screw cap extraction bottles (Nalgene)
 - 5.1.2 Teflon forceps
 - 5.1.3 Polycarbonate filters; 47 mm, 0.45 μm pore size (Nucleopore)
 - 5.1.4 15 ml polyethylene screw cap centrifuge tubes
 - 5.1.5 Sonicator with heated water bath maintained at 65 ± 2 °C
- 5.2 Iron-palladium procedure
 - 5.2.1 50 ml polycarbonate tapered centrifuge tubes with caps.

5.2.2 Centrifuge system

5.2.3 Sonicator with heated water bath maintained at 65 ± 2 °C

6.0 REAGENTS

6.1 APDC

6.1.1 Cobalt nitrate stock solution, 2000 mg/L- Dissolve 2.0 g cobalt metal (Fisher Scientific, certified) in 950 ml of Milli-Q water and 50 ml HNO₃ (Optima)

6.1.2 Cobalt nitrate, 200 mg/L – Dilute 10 ml stock solution (6.1) to 100 ml with Milli-Q water.

6.1.3 Ammonium Pyrrolidine Dithiocarbamate (APDC), 2% solution (Fisher Scientific)- Dissolve 2.0 g APDC in 100 ml Milli-Q water. Store solution at 4 °C; but use at room temperature.

6.1.4 Nitric acid 10%, ultrapure (Optima, Fisher Scientific)- Mix 10 ml HNO₃ into 90 ml Milli-Q water.

6.1.5 Milli-Q water

6.2 Iron-palladium

6.2.1 Nitric acid 20%, ultrapure (Optima, Fisher Scientific)- Mix 20 ml HNO₃ into 80 ml Milli-Q water.

6.2.2 Pure iron and palladium solution made 1:1, 1000 µg/ml (SPEX).

6.2.3 Ammonium hydroxide, concentrated, ultrapure (Optima, Fisher Scientific).

6.2.4 Sodium borohydride, 5% (Fisher Scientific)- Dissolve 0.5 g sodium borohydride in 10 ml Milli-Q water. A fresh solution is made on day of extraction.

6.2.5 Ammonium Pyrrolidine Dithiocarbamate (APDC), 2% (Fisher Scientific)- Dissolve 2.0 g APDC in 100 ml Milli-Q water. Store solution at 4 °C; but use at room temperature.

6.2.6 Milli- Q water

- 6.3 Reagent water-Water that is free from the metal(s) that would potentially interfere at the MDL for the metals listed in Tables 1 and 2. The water is prepared by distillation, deionization, reverse osmosis, anodic/cathodic stripping voltammetry, or other techniques that remove the metals and potential interferants.
- 6.4 Standard Stock Solutions- purchased from a reputable commercial source (Claritas ppt, SPEX CertiPrep Inc; Plasma Cal, SPC Science).

7.0 CALIBRATION AND MAINTENANCE OF THE ICPMS

- 7.1 Trace metal concentrations are determined by comparing the response of a known standard obtained from a certified source traceable to NIST.
- 7.2 An initial calibration curve is performed on the instrument covering the expected range of concentrations in the samples before each batch of samples is run and every 12 hours during sample analyses.
- 7.2.1 Two different commercially available standard solutions are run at three or more concentrations. The calibration standards are diluted to the appropriate levels of the operating range using reagent water containing 1% (v/v) nitric acid.
- 7.2.2 The standard solutions are prepared the day the samples are run. All calibration solutions are spiked with 1 ml of internal standard solution containing 1000ng/ml of Rhodium and Thulium.
- 7.3 The response factor is computed as follows:

$$RF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

A_s : height or area of the response at the m/z for the analyte

C_{is} : concentration of the internal standard in the solution

A_{is} : height or area of the m/z for the internal standard

C_s : concentration of the analyte in the standard or blank solution

- 7.3.1 Compute the mean RF for each analyte using the individual response factors at each concentration.

- 7.3.2 If the RF value range is constant (<20%), the RF value is assumed to be invariant and thus used for calculations. If the range varies significantly, the results can be used to plot a calibration curve of response ratios, A_s/A_{is} vs. RF.

- 7.4 Calibration Verification- Initial calibration verification is performed immediately following calibration. The ICPMS is adjusted until verification criteria are met. After the criteria are met, the blanks and samples may be analyzed.
- 7.5.1 A second-source calibration standard at a mid-level concentration is analyzed before running the samples and then again every 20 samples.
- 7.5.2 Using the mean RF value, the percent recovery of each metal is obtained using the calibration curve in the initial calibration.
- 7.5.3 Compare the recovery of each metal with the corresponding limit for the calibration verification in Table 4. The response for the initial calibration can be used for the blanks and the samples if all of the metals meet the accepted criteria. If a value fails to meet the acceptance range, the system's performance is unacceptable for that compound. The problem should be identified and amended, or a new calibration check standard should be prepared and the test repeated.

Table 4.

METAL	CALIBRATION VERIFICATION
Arsenic	85-115
Cadmium	85-115
Copper	85-115
Lead	85-115
Nickel	85-115
Silver	85-115
Zinc	85-115

Table 4. Quality control acceptance criteria for performance tests for freshwater and effluent samples in EPA method 1640. All specifications are represented as percents. The specifications for cadmium, copper, lead and nickel were calculated from validation conducted on ambient, freshwater samples.

- 7.5 Tuning solution- this solution is used for mass calibration and instrument tuning before analysis. The solution is composed of the same stock solutions that are used to obtain the calibration curve. Internal standards are not added to this solution.
- 7.6 Continuing calibration verification (CCV)- Aliquots of multi-element stock standard is added to an aliquot of reagent water. The CCV is treated as a

sample and digested as the other samples, when applicable. The internal standards are added to the CCV as well.

7.7 An instrument maintenance schedule is maintained for the Hewlett Packard 4500 ICPMS. Dates and initials are recorded in a notebook located near the instrument.

7.7.1 The instrument is serviced by the manufacturer at least once per year.

8.0 QUALITY CONTROL

8.1 QA/QC records are maintained to document the quality of data generated. If any element falls outside the designated range, that element has failed the acceptance criteria. Failure to meet the stated requirement shall require that corrective action be taken to eliminate the problem prior to the analysis of any samples. Samples from the batch being analyzed at the time the failure is detected shall be reanalyzed after the corrective action has been taken. A batch is defined as 20 or less samples. If any sample cannot be reanalyzed, the result for that element shall be flagged and a detailed report is included with the result.

8.1.1 **Lab Blanks-** Two process blanks (reagent blanks), where Milli-Q water is treated as a sample, are run with each batch of samples (15 or less samples). The process blanks are used to assess if there is any internal contamination in the instrument. No element shall be detected at greater than 3 times the method detection limit. A rinse blank is used to flush out the instrument between samples to avoid contamination between samples.

8.1.2 **Field Blanks-** At least one field blank consisting of distilled water in a similar container as the sample container is transported to the sampling site. The blank is exposed to the environment while the actual samples are being collected.

8.1.3 **Matrix Spikes-** A matrix spike and matrix spike duplicate shall be analyzed with each batch of samples to determine precision for each element. A control chart is generated to document the precision. The relative standard deviation for all elements combined shall be within 15% and no single element shall be greater than 20% for those elements that are greater than 10 times the method detection limit.

- 8.1.4 **Duplicate Samples-** Each sample is extracted and analyzed in duplicate. If the duplicates are not in agreement, then the sample is re-extracted and reanalyzed.
- 8.1.5 **CRM/LCM-** Certified reference materials and/or lab control materials shall be analyzed with each batch of samples to evaluate accuracy for each element. The reported value shall be within 15% of the true value.
- 8.1.6 **Initial Calibration Check-** Prior to analyzing any samples, an initial calibration of the instrument is performed with each batch of samples (15 or less). This calibration shall be within 15% of the initial calibration curve (see Section 7.2).
- 8.1.7 **Internal Standards-** Internal standards shall be added in known amounts to blanks, calibration standards, continuing calibration verification solutions, and samples to compensate for instrumental drift. Elements that may be used are presented in Table 5. Relative response factors are used to correct responses of the target analytes.

Table 5. Internal Standards

INTERNAL STANDARD	MASS
Scandium (Sc)	45
Yttrium (Y)	89
Rhodium (Rh)	103
Terbium (Tb)	159
Thulium (Tm)	169
Bismuth (Bi)	209

9.0 SAMPLE COLLECTION, PRESERVATION AND HANDLING

- 9.1 Sampling personnel are required to wear clean, nontalc gloves at all times when handling sampling equipment and sample containers.
- 9.2 Before samples are collected, all sampling equipment and sample containers are cleaned by soaking in a 10% nitric acid solution for a minimum of 24 hours followed by five rinses with Milli-Q water. The bottles are capped and individually double-bagged and placed in a clean plastic box.
- 9.3 Sample bottles are opened only to collect the seawater sample and to add acid preservative. Samples are preserved (at the sampling site or upon

return to the lab) with 1 ml of Optima concentrated nitric acid per liter of sample that will bring the $\text{pH} \leq 2$.

9.3.1 Samples must be acidified within 48 hours of sampling at 4 ± 2 °C until acidified.

9.3.2 Once acidified, the samples must sit for at least 48 hours allowing the acid to completely dissolve the metals absorbed on the walls of the container.

9.3.3 The sample must have a $\text{pH} < 2$. If the pH of the samples is > 2 , more acid will be added and they must sit for 16 hours. The pH must be verified to be < 2 before analysis.

9.4 With each sample set, preserve a field blank, a method blank and a CCV (continuing calibration check) in the same way as the sample(s).

10.0 PROCEDURE

10.1 APDC METHOD

10.1.1 Before a sample can be processed, the sample pH should be verified/adjusted to $\text{pH} \leq 2$. Do not measure the pH directly from the original sample; rather, pour a small aliquot of sample into a separate container to verify the pH .

10.1.2 Transfer a 200 ml aliquot from a well-mixed, acid preserved sample to a pre-calibrated polyethylene bottle.

10.1.3 To the 200 ml sample add 1 ml of 200 mg/L cobalt nitrate solution. Cap the bottle and mix by shaking. Let the solution stand for 2 minutes.

10.1.4 Remove the cap, add 1 ml of 2% APDC and re-cap the bottle and shake gently for 1 minute. This mixture is set aside to react for a minimum of 30 minutes.

10.1.5 The mixture is filtered through an acid cleaned $0.45 \mu\text{m}$ Nucleopore filter using an acid cleaned Millipore vacuum filtration system. The Nucleopore filter is handled with Teflon forceps.

10.1.6 The empty polyethylene bottle that once contained the sample is subsequently rinsed with 5 ml of Milli-Q water (acidified to $\text{pH} 2.0$ with Optima HNO_3) and this is filtered through the Nucleopore filter.

This is repeated 2 times. Finally, the Millipore vacuum filtration cup is rinsed with an adequate amount of acidified Milli-Q water to ensure any particles sticking to the sides are rinsed onto the filter. This final step also ensures that all seawater matrix has been rinsed through the filter.

- 10.1.7 The filter containing the filtrate is removed from the filtration system and folded into quarters ensuring no contact is made with the filtrate. This is then inserted into a 15 ml acid cleaned centrifuge tube.
- 10.1.8 Add 2 ml of 10 % Optima nitric acid into the centrifuge tube containing the filter using a clean pipette.
- 10.1.9 The tube containing the filter is placed in a sonicator with a water bath maintained at 65 ± 2 °C and allowed to digest for 2 hours.
- 10.1.10 Dilute sample (with filter) by adding 8 ml Milli-Q water, re-cap and allow to cool. The sample is now ready for analysis by ICP-MS.
- 10.1.11 The extracts can be stored at 4 ± 2 °C until analysis; however, they should be analyzed as soon as possible after the extraction.
- 10.1.12 Internal standards are added just prior to analysis by ICP-MS.

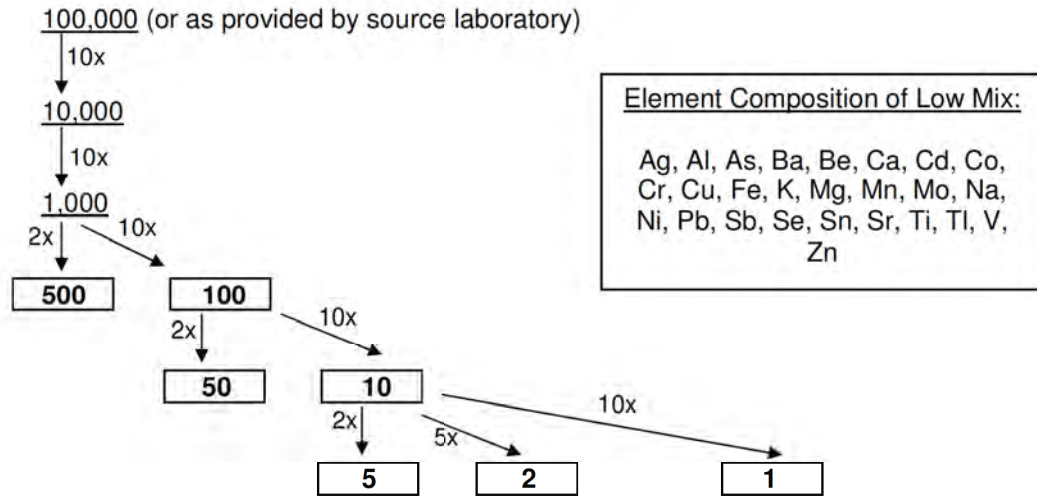
10.2 IRON-PALLADIUM METHOD

- 10.2.1 Before a sample can be processed, the sample pH should be verified/adjusted to $\text{pH} \leq 2$. Do not measure the pH directly from the original sample; rather, pour a small aliquot of sample into a separate container and verify the pH.
- 10.2.2 Transfer a 50 ml aliquot from a well-mixed, acid preserved sample to an acid cleaned 50 ml polycarbonate centrifuge tube.
- 10.2.3
- 10.2.4 To the 50 ml sample add 0.5 ml 1:1 1000 µg/ml of Fe/Pd solution with a clean pipette.
- 10.2.5 Next, add 0.3 ml ammonium hydroxide to the sample and mix by shaking.

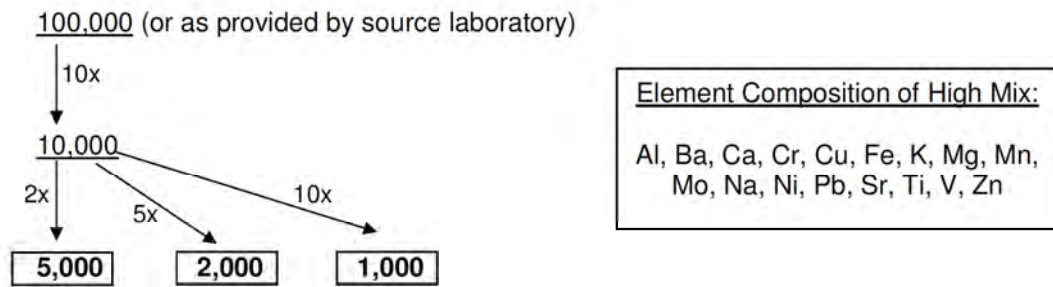
- 10.2.6 Then add 0.5 ml 5% NaBH₄ solution, 0.25 ml 2% APDC solution and mix by shaking. This sample is set aside to react for a minimum of 1 hour.
 - 10.2.7 After a minimum of 1 hour, the sample is centrifuged at 2500 rpm for 30 minutes. Upon completion, the seawater matrix is carefully decanted and discarded.
 - 10.2.8 To the remaining pellet, add 1 ml 20% Optima nitric acid with a clean pipette.
 - 10.2.9 The centrifuge tube is placed in a sonicator with a water bath maintained at 65 ± 2 °C and allowed to digest for 2 hours or until all precipitate is dissolved.
 - 10.2.10 After the digestion is complete and the extract(s) have reached room temperature, the sample(s) can be stored at 4 ± 2 °C until analysis by ICP-MS; however, they should be analyzed as soon as possible. Internal standards can be added just prior to analysis by ICP-MS.
- 10.3 Sample Analysis- Standards are prepared by serial dilutions before each run on the ICPMS. The pipettes and autosampler tubes used for analysis and standards are calibrated before standards are run. Pipettes are calibrated by weighing 1.000 ml of DI water (=1.000 gram) and calibration marks on the autosampler tubes are checked.
- 10.3.1 Use volumetric flasks and calibrated pipettors to make calibration standards by diluting 10 mL of a commercially prepared stock solution to 100 mL. The standard source laboratory and lot number of each of the standards used for each ICPMS run are recorded in the laboratory notebook.
 - 10.3.2 Mix standards by inverting and shaking a minimum of 10 times. A dilution stock of 2% HNO₃ and 1% HCl is used for all dilutions. Prepare 5 concentrations of calibration standards ranging from the method detection limit to at or above the maximum expected concentration in the sample. The standards in the boxes below are used in the calibration curves(see diagrams on pages 16 and 17).

GENERAL CALIBRATION MIX (ng/ml) DILUTIONS

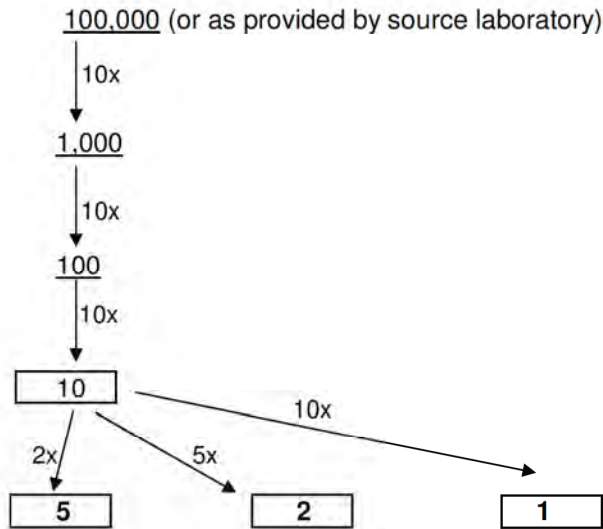
FOR LOW CONCENTRATION SAMPLES



GENERAL CALIBRATION MIX (ng/ml) DILUTIONS
FOR HIGH CONCENTRATION SAMPLES
 (continuation of calibration mix of low concentrations)



CALIBRATION DILUTION FOR MERCURY STANDARDS (ng/ml)



10.3.3 Instrument parameters are stored in the computer program that operates the ICPMS. These parameters are listed in Table 7.

10.3.4

Table 7. Instrument Parameters

PARAMETER	SETTING
RF Power	1350 watts
Acquisition Mode	Spectrum Analysis
Detector Mode	Auto
Acquisition Points/Mass	3
Acquisition Repetitions	3
Argon Flow Rate	16 L/min
Nebulizer	Concentric
Sample Uptake Rate	0.4 mL/min
Sample Uptake Time	90 sec
Pump Stabilization Time	45 sec
Rinse Time	15 sec
Carrier Gas Flow Rate	1.26 L/min
Auxilliary Gas Flow Rate	1.0 L/min
Spray Chamber Temperature	2 °C
Sample Depth	7.5 mm ¹⁸

10.3.5 Fill the autosampler rinse container with deionized water.

- 10.3.6 Empty the spray chamber drain bottle and fill to approximately 1/4 full with tap water. It is important that the drain line from the spray chamber be immersed in water to prevent fluctuations in the plasma.
- 10.3.7 Turn on the argon gas supply.
- 10.3.8 Ignite the plasma and allow a minimum of 30 minutes for stabilization.
- 10.3.9 Check the system operating conditions by tuning the instrument according to the parameters listed in Table 8. If parameters do not fall within these limits, retune the instrument per manufacturer's procedures. Once you are satisfied with the tune, save the parameters and print out a copy for the laboratory notebook.

Table 8 Optimal Tune Results

PARAMETER	OPTIMAL RESULT
Sensitivity for AMU 2	7,000 counts
Sensitivity for AMU 89	15,000 counts
Sensitivity for AMU 205	10,000 counts
RSD for AMU 2, 89, & 205	< 5%
Pulse to Analog Factors	100 ± 1
Doubly Charged Ions	< 3%
Oxides	< 1%
Axis	± 0.05 AMU
Peakwidth	0.65 - 0.75 AMU at 10%

- 10.3.10 Load the appropriate method file into the Chemstation data system. Complete the sample sequence table with the specified sample information and dilution factors. Load the samples into the autosampler according to the order listed in the sequence file. Double check to make sure the standards, blanks, and samples are in the correct autosampler position assigned in the sequence file.

NOTE: The instrument may be set for automatic shutoff at the end of the sequence by adding the following command in the last line of the sequence file:

TYPE = Keyword

KEYWORD = Command

KEYWORD COMMAND = tune "macro`shutdown.mac`.go"
(this must be typed exactly as written here)

10.3.11 Start the analytical sequence and make sure that it is operating properly.

11.0 CALCULATIONS

11.1 For water samples, concentration factors necessary for the subsequent ICP-MS analyses are calculated by dividing the original seawater volume by the final digestate volume.

APPENDIX B

TAC MEMBER PROFILES

Richard F. Ambrose

Professor, Department of Environmental Health Sciences, University of California, Los Angeles

(a) Professional Preparation

University of California, Irvine	Biological Sciences	B.S., 1975
University of California, Los Angeles	Ecology	Ph.D., 1982
Simon Fraser University	Ecology	Postdoc., 1983-84

(b) Appointments

1992-present	Professor (2000-present) and Associate Professor (1992-2000), Department of Environmental Health Sciences and the Institute of the Environment and Sustainability, UCLA
1998-2011	Director, Environmental Science and Engineering Program, UCLA
1985-1992	Assistant/Associate Research Biologist, Marine Science Institute, University of California, Santa Barbara

(c) Publications (Selected from 206 total, with 98 peer-reviewed journal articles)

- Doughty, C.L., K.C. Cavanaugh, R.F. Ambrose and E.D. Stein. *In press*. Evaluating regional resiliency of coastal wetlands to sea level rise through hypsometry-based modeling. *Global Change Biology*.
- Rosencranz, J.A., K.M. Thome, K.J. Buffington, J.Y. Takekawa, R.F. Hechinger, T.E. Stewart, R.F. Ambrose, G.M. MacDonald, M.A. Holmgren, J.A. Crooks, R.T. Patton, and K.D. Lafferty. 2018. Sea-level rise, habitat loss, and potential extirpation of a salt marsh specialist bird in urbanized landscapes. *Ecology and Evolution* 8: 8115-8125. DOI: 10.1002/ece3.4196.
- Saaman, E.T., B. Owens, S.N. Murray, S.B. Weisberg, R.F. Ambrose, J.C. Field, K.J. Nielsen, and M.H. Carr. 2018. An ecological framework for informing permit decisions on scientific activities in protected areas. *PLOS ONE* 13(6): e0199126. <https://doi.org/10.1371/journal.pone.0199126>.
- Miner, C.M., J.L. Bumaford, R.F. Ambrose, L. Antrim, H. Bohlmann, C.A. Blanchette, J.M. Engle, S.C. Fradkin, R. Gaddam, C.D.G. Harley, B.G. Miner, S.N. Murray, J.R. Smith, S.G. Whitaker and P.T. Raimondi. 2018. Large-scale impacts of sea star wasting disease (SSWD) on intertidal sea stars and implications for recovery. *PLOS ONE* 13(3): e0192870. <https://doi.org/10.1371/journal.pone.0192870>.
- Yap, T.A., M.S. Koo, R.F. Ambrose and V.T. Vredenberg. 2018. Historical evidence suggests introduced amphibian facilitated the invasion of a fungal pathogen to western North America. *PLOS ONE* 13(4): e0188384. <https://doi.org/10.1371/journal.pone.0188384>.
- Thome, K., G. MacDonald, G. Guntenspergen, R. Ambrose, K. Buffington, B. Dugger, C. Freeman, C. Janousek, L. Brown, J. Rosencranz, J. Holmquist, J. Smol, K. Hargan, J. Takekawa. 2018. U.S. Pacific coastal wetland resilience and vulnerability to sea-level rise. *Science Advances* 4:eaa03270. 10 pp. DOI: 10.1126/sciadv.aao3270.
- Parker, E.A., M.A. Rippy, A.S. Mehring, B.K. Winfrey, R.F. Ambrose, L.A. Levin, and S.B. Grant. 2017. The Predictive Power of Clean Bed Filtration Theory for Fecal Indicator Bacteria Removal in Stormwater Biofilters. *Environmental Science and Technology* 51: 5703-5712. DOI: 10.1021/acs.est.7b00752.
- Fong, L.S., E. D. Stein and R.F. Ambrose. 2017. Development of restoration performance curves for streams in southern California using an integrative condition index. *Wetlands* 37: 289-299.
- Winfrey, B.K., B.E. Hatt and R.F. Ambrose. 2017. Arbuscular mycorrhizal fungi in Australian stormwater biofilters. *Ecological Engineering* 102: 483-489.
- Rosencranz, J.R., L.N. Brown, J.R. Holmquist, Y. Sarchez, G.M. MacDonald and R.F. Ambrose. 2017. The role of sediment dynamics for inorganic accretion patterns in southern California's Mediterranean-climate salt marshes. *Estuaries and Coasts*. DOI: 10.1007/s12237-017-0224-3.
- Ambrose, R.F. 2017. Managing Sea Level Rise in Coastal Wetlands: Testing Thin Layer Sediment Augmentation as an Adaptation Strategy. Proceedings of the US-Iran Symposium on Wetlands, March 28-30, 2016, in Irvine, CA. University of Arizona, National Academies, and Sharif University of Technology. pp. 149-160.
- Mehring, A.S., B.E. Hatt, D. Kraikittikun, B.D. Orelo, M.A. Rippy, S.B. Grant, J.P. Gonzalez, S.C. Jiang, R.F. Ambrose and L.A. Levin. 2016. Soil invertebrates in Australian rain gardens and their potential roles in storage and processing of nitrogen. *Ecological Engineering* 97: 138-143.

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13. Thome, K.M., MacDonald, G.M., Ambrose, R.F., Buffington, K.J., Freeman, C.M., Janousek, C.N., Brown, L.N., Holmquist, J.R., Guntenspergen, G.R., Powelson, K.W., Barnard, P.L., and Takekawa, J.Y., 2016, Effects of climate change on tidal marshes along a latitudinal gradient in California: U.S. Geological Survey Open-File Report 2016-1125, 75 p. Available at: <http://dx.doi.org/10.3133/ofr20161125>.
14. Rosencranz, J.A., N.K. Ganju, R.F. Ambrose, S.M. Brosnahan, P.J. Dickhudt, G.R. Guntenspergen, G.M. MacDonald, J.Y. Takekawa and K.M Thome. 2016. Balanced sediment fluxes in southern California's Mediterranean-climate zone salt marshes. *Estuaries and Coasts* 39: 1035-1049. DOI 10.1007/s12237-016-0077-1. Erratum published online 17 February 2016.
15. Murray, S.N., S.B. Weisberg, P.T. Raimondi, R.F. Ambrose, C.A. Bell, C.A. Blanchette, J.L. Burnaford, M.N. Dethier, J.M. Engle M.S. Foster, C.M. Miner, K.J. Nielsen, J.S. Pearse, D.V. Richards, and J.R. Smith. 2016. Evaluating ecological states of West Coast rocky intertidal communities: A best professional judgment exercise. *Ecological Indicators* 60: 802-814.
16. Wang, W., Y.Ding, J.L. Ullman, R.F. Ambrose, Y. Wang, X. Song and Z. Zhao. 2016. Nitrogen removal performance in planted and unplanted horizontal subsurface flow constructed wetlands treating different influent COD/N ratios. *Environmental Science and Pollution Research*. Pages 1-7. Published online 29 January 2016. DOI 10.1007/s 11356-016-6115-S
17. Ferguson, D., G.N. Talavera, L.R. Hernandez, R.F. Ambrose, J.A. Jay and S. Weisberg. 2016. Virulence genes among *Enterococcus faecalis* and *Enterococcus faecium* isolated from coastal beaches and potential sources in southern California and Puerto Rico. *Journal of Pathogens*. 7 pages. DOI 10.1155/2016/3437214.
18. Yap, T.A., M.S. Koo, R.F. Ambrose, D.B. Wake and V.T. Vredenburg. 2015. Averting a biodiversity crisis. *Science* 349: 481-482.
19. Ambrose, R.F. and B.K. Winfrey. 2015. Comparison of stormwater biofiltration systems in southeast Australia and southern California. *WIREs Water* 2: 131-146. DOI: 10.1002/wat2.1064
20. Myers, M.R. and R.F. Ambrose. 2015. Salt marsh reduces fecal indicator bacteria input to coastal waters in southern California. *Bulletin of the Southern California Academy of Sciences* 114: 76-88.
21. Needles, L.A., S.E. Lester, R. Ambrose, A. Andren, M. Beyeler, M.S. Connor, J.E. Eckman, B.A. Costa-Pierce, S.D. Gaines, K.D. Lafferty, H.S. Lenihan, J. Parrish, M.S. Peterson, A.E. Scaroni, J.S. Weis, D.E. Wendt. 2015. Managing bay and estuarine ecosystems for multiple services. *Estuaries and Coasts* 38 (Suppl. 1): S35-S48.
22. Ambrose, R.F., J.H. Dorsey, K.K. Johnston, and E.D. Stein. 2015. State of the Bay Report. "Habitat Conditions: Coastal Wetlands." *Urban Coast* 5(1): 59-68. Available online: <http://urbancoast.org/>.
23. Altstatt, J., R. Ambrose, J. Carroll, J. Coyer, J. Wible and J. Engle. 2014. Eelgrass meadows return to Frenchy's Cove, Anacapa Island: Recovery ten years after successful transplantation. *Monographs of the Western North America Naturalist* 7: 500-517.
24. Zimmer-Faust, A.G., R.F. Ambrose and M.N. Tambwiti. 2014. Evaluation of approaches to quantify total residual oxidants in ballast water management systems employing chlorine for disinfection. *Water Science and Technology* 70: 1585-1593. DOI: 10.2166/wst.2014.394.
25. Grant, S.B., J-D Saphores, D.L. Feldman, A.J. Hamilton, T.D. Fletcher, P.L.M. Cook, M. Stewardson, B.F. Sanders, L.A. Levin, R.F. Ambrose, A. Deletic, R. Brown, S.C. Jiang, D. Rosso, W.J. Cooper and I. Marusic. 2012. Taking the "waste" out of "wastewater" for human water security and ecosystem sustainability. *Science* 337: 681-686.
26. Peterson, C.H., S.S. Anderson, G.N. Cherr, R.F. Ambrose, S. Anghera, S. Bay, M. Blum, R. Condon, T.A. Dean, M. Graham, M. Guzy, S. Hampton, S. Joye, J. Lambinos, B. Mate, D. Meffert, S.P. Powers, P. Somasundaran, R.B. Spies, C.M. Taylor, R. Tjeerdema, and E.E. Adams. 2012. A Tale of Two Spills: Novel Science and Policy Implications of an Emerging New Oil Spill Model. *Bioscience* 62: 461-469.
27. Willette, D.A. and R.F. Ambrose. 2012. Effects of the invasive seagrass *Halophila stipulacea* on the native seagrass, *Syringodium filiforme*, and associated fish and epibiota communities in the eastern Caribbean. *Aquatic Botany* 103: 74-82.
28. Coffman, G.C., R.F. Ambrose and P.W. Rundel. 2011. Wildfire promotes dominance by the invasive Giant Reed (*Arundo donax*) in riparian ecosystems. *Biological Invasions* 12: 2723-2734.
29. Stein, E.D., D. Ackerman, T. Hogue, S. Lopez, R. Ambrose and V. Chan. 2010. Effect of global climate change on southern California coastal wetlands. Report to the State of California Department of Water Resources.
30. Rothenberg, S.E., M.E. Kirby, B.W. Bird, M.B. DeRose, C. Lin, X. Feng, R.F. Ambrose and J.A. Jay. 2010. The impact of over 100 years of wildfires on mercury levels and accumulation rates in two lakes in southern California, USA. *Environmental Earth Sciences* 60: 993-1005.

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31. Myers, M.R. and R.F. Ambrose. 2009. Differences in benthic cover inside and outside marine protected areas on the Great Barrier Reef: influence of protection or disturbance history? *Aquatic Conservation: Marine and Freshwater Ecosystems* 19: 736-747.
32. Smith, J.R., P. Fong and R.F. Ambrose. 2009. Spatial patterns in recruitment and growth of the mussel *Mytilus californianus* (Comad) in southern and northern California, USA, two regions with differing oceanographic conditions. *Journal of Sea Research* 61: 165-173.
33. Willette, D.A. and R.F. Ambrose. 2009. The distribution and expansion of the invasive seagrass *Halophila stipulacea* in Dominica, West Indies, with a preliminary report from St. Lucia. *Aquatic Botany* 91: 137-142.
34. Smith, J.R., P. Fong and R.F. Ambrose. 2008. The impacts of human visitation on mussel bed communities along the California coast: Are regulatory marine reserves effective in protecting these communities? *Environmental Management* 41: 599-612.
35. Rothenberg, S.E., R.F. Ambrose and J.A. Jay. 2008. Mercury cycling in surface water, pore water and sediments of Mugu Lagoon, CA, USA. *Environmental Pollution* 154: 32-45.
36. Pankratz, S., T. Young, H. Cuevas-Arellano, R. Kumar, R.F. Ambrose and I.H. Suffet. 2007. The ecological value of constructed wetlands for treating urban run-off. *Water Science and Technology* 55: 63-69.
37. Tetreault, I. and R.F. Ambrose. 2007. Temperate marine reserves enhance targeted but not untargeted fishes in multiple no-take MPAs. *Ecological Applications* 17: 2251-2267.
38. Swenson, D.P. and R.F. Ambrose. 2007. A Spatial Analysis of Cumulative Habitat Loss in Southern California under the Clean Water Act Section 404 Program. *Landscape and Urban Planning* 82: 41-55.
39. Miller, A.W., G.M. Ruiz, M.S. Minton and R.F. Ambrose. 2007. Differentiating successful and failed molluscan invaders in marine ecosystems. *Marine Ecology Progress Series* 332: 41-51.
40. Raimondi, P., R. D. Sagarin, R. Ambrose, C. Bell, M. George, S. Lee, D. Lohse, C.M. Miner, and S. Murray. 2007. Consistent frequency of color morphs in the sea star *Pisaster ochraceus* (Echinodermata: Asteroidea) across open-coast habitats in the northeastern Pacific. *Pacific Science* 61: 197-206.
41. Sagarin, R.D., R.F. Ambrose, B.J. Becker, J.M. Engle, J. Kido, S.F. Lee, C.M. Miner, S.N. Murray, P.T. Raimondi, D.V. Richards, C. Roe. 2007. Ecological impacts on the limpet *Lottia gigantea* populations: human pressure over a broad scale on islands and mainland intertidal zones. *Marine Biology* 150: 399-415.
42. Smith, J.R., R.F. Ambrose, and P. Fong. 2006. Long-term change in mussel (*Mytilus californianus* Comad) populations along the wave-exposed coast of California. *Marine Biology* 149: 537-545.
43. Smith, J.R., R.F. Ambrose, and P. Fong. 2006. Dramatic declines in mussel bed community diversity: Response to climate change? *Ecology* 87: 1153-1161.
44. Forrester, G.E., B.I. Fredericks, D. Gerdeman, B. Evans, M.A. Steele, K. Zayed, L.E. Schweitzer, I.H. Suffet, R.R. Vance and R.F. Ambrose. 2003. Correspondence between field-measured growth rates of fish from several California estuaries and the inferred toxicity of multiple sediment contaminants. *Marine Environmental Research* 56: 423-442.
45. Raimondi P., M. Wilson, R. Ambrose, J. Engle and T. Minchinton. 2002. Continued declines of black abalone along the coast of California: Are mass mortalities related to El Niño events? *Marine Ecology Progress Series* 242: 143-152.
46. Miller, A.W. and R.F. Ambrose. 2000. Optimum sampling of patchy distributions: Comparison of different sampling designs in rocky intertidal habitats. *Marine Ecology Progress Series* 196: 1-14.
47. Murray, S.N., R.F. Ambrose, J.A. Bohnsack, L.W. Botsford, M.H. Carr, G.E. Davis, P.K. Dayton, D. Gotshall, D.R. Gunderson, M.A. Hixon, J. Lubchenco, M. Mangel, A. MacCall, D.A. McArdle, J.C. Ogden, J. Roughgarden, R.M. Starr, M.J. Tegner and M.M. Yoklavich. 1999. No-take reserve networks: Protection for fishery populations and marine ecosystems. *Fisheries* 24: 11-25.
48. Palmer, M.A., R.F. Ambrose and N.L. Poff. 1997. Ecological theory and community restoration ecology. *Restoration Ecology* 5: 291-300.

(d) Synergistic Activities

Southern California Wetlands Recovery Project Science Advisory Panel; California Coastal Commission's Science Advisory Panels for the SONGS and Poseidon Mitigation Programs; Santa Monica Bay National Estuary Program Technical Advisory Committee; California Ocean Protection Council Science Advisory Team; California Marine Life Protection Act Initiative (South Coast) Science Advisory Team (2008-9); U.S. Army Corps of Engineers Environmental Advisory Board (2007-13); Science Advisory Committees for Malibu Lagoon Restoration (2003-5), Ballona Wetland Restoration (2005-9), Santa Clara River Estuary Restoration, Bunker Point Artificial Reef, Ormond Beach Wetland Restoration, Aliso Creek Estuary Restoration, Tijuana Estuary Restoration, San Elijo Lagoon Restoration.

CURRICULUM VITAE

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E-mail: campbell@inrs.ca

BIRTH/CITIZENSHIP May 4, 1943 / Canadian

MARITAL STATUS Married, 3 children

ACADEMIC QUALIFICATIONS

BSc (Honours): Bishop's University, 1963
Chemistry / Physics

PhD: Queen's University, 1968
Organic / Organometallic Chemistry

AWARDS

2011 Distinguished Visiting Scientist award, CSIRO Land and Water, Australia
2010 Honorary doctorate, Universite de Bordeaux I, Bordeaux, France
2006 Excellence in Review Award, Environmental Science and Technology Journal,
American Chemical Society, Washington, DC, USA
2002 Elected Fellow, Royal Society of Canada
2001 Canada Research Chair, Metal Ecotoxicology
2001 Synergy Award for Innovation, Research and Development Partnerships, Natural
Sciences and Engineering Research Council (NSERC) and Conference Board of
Canada, co-winner with colleagues from McMaster University.
2000 Chandler-Misener Award, International Association for Great Lakes Research (jointly
with Dr. M.R. Twiss)
1998 Ministere de l'Education nationale, de l'Enseignement superieur et de la Recherche
(MENESR, France), Accueil de chercheurs etrangers en France, Bourse de Haut Niveau
1994, 1986 Prix d'excellence en recherche, Institut national de la Recherche scientifique
1989 Association canadienne franyaise pour l'avancement des sciences
Prix Michel Jurdant (Environmental science): Co-winner with Dr. A. Tessier
1968 - 1970 National Research Council (Canada), postdoctoral fellowship
1964 - 1967 National Research Council (Canada), postgraduate scholarship
1963 - 1964 Woodrow Wilson Fellowship

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EXPERIENCE

- 2016- **Emeritus Professor**, Université du Québec, Institut national de la recherche scientifique, INRS-Eau
- 1983 -2015 **Professor**, Université du Québec, Institut national de la recherche scientifique, INRS-Eau
- 1978-1982 **Director**, Université du Québec, Institut national de la recherche scientifique, INRS-Eau
- 1970-1978 Université du Québec, Institut national de la recherche scientifique, INRS-Eau, **Associate Professor**, 1973-78; **Assistant Professor**, 1970-73
- 1968-1970 Monash University, Department of Chemistry, Melbourne, Australia, **Postdoctoral Fellow** and Lecturer
-
- 1999-2004 Metals in the Environment Research Network (MITE-RN), **Research Director** and **Principal Investigator** (www.mite-rn.org)
- 2005-2009 Metals in the Human Environment Research Network (MITRE-RN), **Aquatic Theme Co-Director** (www.mithe-rn.org)
-
- 2011-2012 CSIRO Land and Water Directorate, Environmental Contaminants Division, Adelaide
2004-2005 Laboratory, Waite Institute, Urrbrae, South Australia, **Visiting Scientist** (sabbatical leave)
- 1998 Université de Bordeaux I, Laboratoire d'écophysiologie et ecotoxicologie des systèmes aquatiques (LEESA), Arcachon, France, **Visiting Professor** (sabbatical leave)
- 1997-1998 CSIRO Centre for Advanced Analytical Chemistry, Lucas Heights Research
1990-1991 Laboratories, Menai, New South Wales, Australia, **Visiting Scientist** (sabbatical leave)
- 1982-1983 Stanford University, Department of Civil Engineering, Environmental Engineering and Science Section, Stanford, California, USA, **Visiting Professor** (sabbatical leave)
- 1976-1977 Freshwater Biological Association, River Laboratory, East Stoke, Dorset, U.K., **Visiting Scientist** (sabbatical leave)

RESEARCH INTERESTS:

Biogeochemistry of metals in the aquatic environment: current research topics include elements of analytical chemistry (development and refinement of methods to determine metal speciation), geochemistry (identification of factors controlling metal speciation in natural waters) and ecotoxicology (development of predictive models relating the biological response elicited by a metal to its speciation in the external medium). Metals of current interest include Al, Ag, Mn, Cd, Cu, Hg, Pb, Zn + Pd, Pd, La, Ce; target organisms include freshwater algae, rooted aquatic plants, benthic invertebrates, and fish. The biological responses of interest are metal bioaccumulation within the target organism, metal detoxification (transcriptome; proteome), and metal-induced changes in physiology and growth.

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COMMITTEES (current)

- International Copper Association, International Lead Zinc Research Organization, Nickel Producers Environmental Research Association - Ecotoxicity Technical Advisory Panel (ETAP), Member 2000- ...
- International Scientific Council, Centre d'Ecotoxicologie et Toxicologie Environnementale de Rovaltain, France, Member 2009- ... ; Chair 2014- ...
- Co-editor, Cambridge Environmental Chemistry Series, Cambridge University Press, UK, 1988- ...
- Editorial Board, Journal *"Revue des Sciences de l'Eau"* 1993- ...
- Editorial Board, Journal *"Environmental Chemistry"*, 2004- ...

PAST COMMITTEES (partial list)

- Agence nationale de la Recherche, France, Comite Ecosystemes et Sante, Member, 2008-2010; Comite de selection, BIOADAPT, 2011-2013
- Agence nationale de la Recherche, France), Comite sectoriel, Ecosystemes et Developpement durable, Member 2010-2013.
- Society of Environmental Toxicology and Chemistry (SETAC), Advisory Group on Metals, Member 2000-2006.
- Environment Canada/ Health Canada Chemical Management Plan (CMP) Science Committee, Member 2013-16 (<http://www.chemicalsubstanceschimigues.gc.ca/plan/sc-cs/index-eng.php>)
- Environment Canada, Categorization of inorganic substances on the Domestic Substances List (Canadian Environmental Protection Act), Inorganic Working Group, Member, 1999-2004.
- Canadian Foundation for Innovation, University Research Development Fund Committee, Member, 1999-2002.
- Natural Resources Canada, Aquatic Effects Technology Evaluation programme, Technical Committee; Member, 1995-98.
- Health Canada, Expert Steering Committee, Aluminum and animal neurotoxicity study, Member, 1999-2008.
- Natural Sciences and Engineering Research Council of Canada (NSERC), Advisory Committee on University-Industry Grants (ACUIG), Co-Chair, 2015-17.
- Natural Sciences and Engineering Research Council of Canada (NSERC), Advisory Committee on University-Industry Grants (ACUIG), Member, 2006-2009.
- Natural Sciences and Engineering Research Council of Canada (NSERC), Advisory Group on Interdisciplinary Research (AGIR), Member, 2000-2008.
- Natural Sciences and Engineering Research Council of Canada (NSERC), Committee on Collaborative Research Initiatives; Member 1991-95; Chair 1993-95.

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- Natural Sciences and Engineering Research Council of Canada (NSERC), Interdisciplinary Grant Selection Committee; Member, 1988-1991; Chairman, 1989-1990.
- Fonds pour la Formation de Chercheurs et l'Aide à la Recherche (FCAR), Comité de sélection pour l'équipement de recherche, Member 1999-2000, Chair 2000-01.
- Fonds pour la Formation de Chercheurs et l'Aide à la Recherche (FCAR), Comité du programme <Centres de recherche>; Member 1986-1988; Chair 1987-1988.
- National Research Council of Canada (NRCC), Associate Committee on Hydrology; Member, 1985-1991; Executive committee, 1987-1990
- National Research Council of Canada (NRCC), Associate Committee on Scientific Criteria for Environmental Quality; Member, 1987-1991; Member, Water Subcommittee, 1983-1985; Member, Manganese working group, 1984-1986; Co-chairman, Working group on the bio-availability of metals in sediments, 1984-1988.
- National Research Council of Canada (NRCC), Committee on Marine Analytical Chemistry; Member, 1986-1989.
- Royal Society of Canada, Global Climate Change Program, Committee on Acid Precipitation; Member, 1989-92.
- Royal Society of Canada/ U.S. National Academy of Sciences/ Mexican Academia de la Investigación Científica: Joint Committee on Acid Precipitation; Member, 1981-1985.
- International Joint Commission (Canada/U.S.A.), Great Lakes Science Advisory Board; Member 1985-1987.
- Hydro-Quebec, Environmental Advisory Committee, 1988-1990.
- Canadian Association for Water Pollution Research and Control (CAWPRC), Executive, 1978-1982; 1983-90; Vice-president, development, 1989-1990.

CONFERENCES (partial list)

- Co-Chair, Symposium on Metallomics - Metal speciation in living cells, Canadian Society for Chemistry, May 2013, Quebec.
- Co-Chair, Symposium on Speciation and Bioavailability of Metals, Canadian Society for Chemistry, June 2011, Montreal.
- Co-Chair, Symposium on Site-specific Community-Based Risk Assessments for Metals, Society for Environmental Toxicology and Chemistry (SETAC), World Congress, August 2008, Sydney, Australia.
- Co-Chair, Symposium on Environmental Risk Analysis for Metals, Society for Environmental Toxicology and Chemistry (SETAC), Annual Meeting, November 2006, Montreal.
- Chair 4^e Colloque annuel, Chapitre St-Laurent, Qualité de l'Environnement - concepts et outils, June 2000, Quebec
- Co-chair (with Dr. R.J. Allan), International Symposium on the Fate and Effects of Toxic Chemicals in Large Rivers and their Estuaries, October 1988, Quebec.

CV (PGC Campbell) ... 5

- Chair, International Symposium on Trace Metal Speciation, Canadian Society for Chemistry, June 1987, Quebec; Organizer, Scientific Programme, Analytical Chemistry Division, 70th Canadian Chemical Congress, June 1987, Quebec.
- Chair, International Symposium on Reservoir Ecology and Management (UNESCO/Hydro-Quebec / James Bay Energy Society), June 1981, Quebec.

RECENT CONSULTATIONS (partial list)

- Natural Resources Canada, CANMET, Mine Environment Neutral Drainage (MEND) program, Report on *How to Assess Possible Biological Effects of Sub-Aqueous Disposal of Reactive Mine Tailings - Literature Review and Recommended Tools and Methodologies*, 2017-present.
- Grand Council of the Cree, Ouje-Bougoumou Cree Community. Co-chair of the Steering Committee overseeing the ecological risk assessment of metal mining activities in the traditional Cree territory near Chibougamau, Quebec, 2003-present.
- Rio Tinto Fer et Titane Inc. Geochemical characterization of the interstitial water and sediments of Lake Petit-Pas, Charlevoix, Quebec, 2008-2009; 2017-present.
- National Defence Canada. Evaluation of the bioavailability of silver present in drainage waters from the Munitions Experimental Test Centre, Nicolet, Quebec, 2007.
- Government of New Caledonia ("Province du Sud"). Member of the Expert committee formed to evaluate the environmental impacts of the effluent from the projected Gorn nickel mine, 2006-2008.
- Broken Hill Proprietary (Melbourne, Australia). Member of Peer Review Committee formed to assess the effects of the Ok Tedi copper mine on the downstream environment, Papua New Guinea, 1997-2001.

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Canadian Society for Chemistry (CSC), Ottawa
 Association for the Sciences of Limnology and Oceanography (ASLO)
 Society of Canadian Limnologists (SCL)
 Society of Environmental Chemistry and Toxicology (SETAC)

PUBLICATIONS SUMMARY (Web of Science Researcher ID: H-4348-2011)

Articles in refereed journals	205
Publications in conference proceedings	36
Book chapters	23
Refereed reports	3
Technical reports	52
Edited volumes	2
Invited communications	41

CURRICULUM VITAE: Gary N. Cherr

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Home Address

4971 Acacia Way
 Pennngrove, CA 94951
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 Cell (707) 799-9947

Education and Training:

B.A. Biology, Sonoma State University, 1979
 Ph.D. Zoology, University of California, Davis 1984
 National Institutes of Health Postdoctoral Fellow, Department of Obstetrics and Gynecology,
 School of Medicine, University of California, Davis, 1983-1986.

Areas of Specialization: reproductive physiology, reproductive and developmental biology and toxicology, sperm cell physiology, embryo defense mechanisms, biochemistry and cell biology of environmental stress, endocrine disruption, environmental toxicology, oil spill impacts

Current Appointments:

Director (2009-present), UC Davis Bodega Marine Laboratory
 Professor (1999-present), UC Davis Departments of Environmental Toxicology and Nutrition

Professional Experience:

Acting Director, Bodega Marine Laboratory, 2007-2008
 Research Biologist (1993-1999), Bodega Marine Laboratory and Dept. Environmental
 Toxicology, University of California, Davis, 1999

Service: *University of California*

Study Section Member for Tobacco-Related Disease Research Program, Office of the President
 of the University of California, 1990
 Steering Committee for University of California at Santa Barbara, Southern California Education
 Initiative, U.S. Department of Interior, 1990-1994
 California Sea Grant College Program Advisory Board Member, 2003-present
 California Sea Grant College Program Advisory Board Chair, 2005-present
 University of California Marine Council, 2007-2008
 Executive Board, Cooperative Institute for Marine Ecosystems and Climate (NOAA and UC San
 Diego), 2011-2015.

Service: *Non-University*

Science Advisory Board, San Francisco Bay Estuary Project, 1988-1990
 Biomonitoring Science Advisory Board, Department of Ecology, State of Washington, 1991-
 1995
 Advisor, US Regional Marine Research Board, Pacific Northwest Region, Washington State Sea

Gary N. Cherr, Ph.D.
Curriculum Vitae

Grant College Program, 1992-1993
 Protocol Review Committee, Water Resources Control Board, State of California, 1994-2000
 Technical Review Panel, Department of Ecology, State of Washington, 1998
 Toxicity Identification Evaluation Review Committee, US EPA, 1999-2000
 Organizer of 2000 Western Regional Developmental Biology Conference, Society for
 Developmental Biology, Bodega Marine Laboratory
 Exxon Valdez Oil Spill Trustee Council Science Panel, 2006-present
 State of California Resources Agency Science Sea Grant Advisory Panel, 2007-2010
 Technical Advisory Committee, Coastal Conservancy Creosote Removal Project, 2014-present

Selected Publications (150 total):

- Cherr, G.N. and Wallis H. Clark, Jr. 1982. Fine structure of the envelope and micropyles in the eggs of the white sturgeon, *Acipenser transmontanus* Richardson. *Development Growth and Differentiation* 24:341-352.
- Cherr, G.N. and W.H. Clark, Jr. 1984. An acrosome reaction in sperm from the white sturgeon, *Acipenser transmontanus*. *Journal of Experimental Zoology* 232(1):129-139.
- Cherr, G.N. and W.H. Clark, Jr. 1985. Gamete interaction in the white sturgeon, *Acipenser transmontanus*: A morphological and physiological review. *Environmental Biology of Fishes* 14(1):11-22.
 Also in: *North American Sturgeons: Biology and Aquaculture Potential*, F. Binkowski and S. Doroshov (eds.), Dordrecht: Dr W. Junk; pp 11-22.
- Cherr, G.N. and W.H. Clark, Jr. 1986. Induction of the acrosomal reaction in sperm from the white sturgeon, *Acipenser transmontanus*, pp 235-249, In: J.L. Hedrick (ed.) *The Molecular and Cellular Biology of Fertilization*, Plenum Publishing Corporation, New York, New York.
- Cherr, G.N., J. Shenker, C. Lundmark and K.O. Turner. 1987. Toxic effects of selected bleached kraft mill effluent constituents on the sea urchin sperm cell. *Environmental Toxicology and Chemistry*, 6:561-569.
- Cherr, G.N., J. Shoffner-McGee, and J.M. Shenker. 1990. Methods for assessing fertilization and embryonic/larval development in toxicity tests using the California mussel (*Mytilus californianus*). *Environmental Toxicology and Chemistry*, 9:1137-1145.
- Shenker, J.M., and G.N. Cherr. 1990. Toxicity of zinc and bleached kraft mill effluent to larval English sole (*Parophrys vetulus*) and topsmelt (*Atherinops affinis*) *Archives of Environmental Contamination and Toxicology*, 19:680-686.
- Cherr, G.N. 1990. Toxicity tests for *Mytilus californianus* (California mussel). In: *Proceedings of A Workshop on Culture and Toxicity Testing of West Coast Marine Organisms*. G.A. Chapman, ed., U.S. Environmental Protection Agency Publication pp. 89-94.

Gary N. Cherr, Ph.D.
Curriculum Vitae

- Cherr, G.N., R.G. Summers, J.D. Baldwin, and J.B. Morrill. 1992. Preservation and visualization of the sea urchin blastocoelic extracellular matrix. *Microscopy Research and Technique*, 22:11-22.
- Baldwin, J.D., M.C. Pillai, and G.N. Cherr. 1992. The response of sea urchin (*Strongylocentrotus purpuratus*) embryos to aqueous petroleum wastes includes the expression of a high molecular weight glycoprotein. *Marine Biology*, 114: 21-30.
- Pillai, M.C., J.D. Baldwin, and G.N. Cherr. 1992. Early development in an algal gametophyte: Role the cytoskeleton in germination and nuclear translocation. *Protoplasma*, 170:34-45. DOI: 10.1007/BF01384455
- Yanagimachi, R., G.N. Cherr, M.C. Pillai, and J.D. Baldwin. 1992. Factors controlling sperm entry into the micropyles of salmonid and herring eggs. *Development, Growth, Differentiation*, 34:447-461.
- Higashi, R.M., G.N. Cherr, J.M. Shenker, J.M. Macdonald, and D.G. Crosby. 1992. A Polar high molecular mass constituent of bleached kraft mill effluent is toxic to marine organisms. *Environmental Science and Technology*, 26:2413-2420.
- Higashi, R.M., G.N. Cherr, C.A. Bergens, T.W-M. Fan, and Crosby, D.G. 1992. Toxicant isolation from a produced water source in the Santa Barbara Channel. In: *Produced Water: Technological/Environmental Issues and Solutions*. J.P. Ray and F.R. Engelhardt, eds. Plenum Press, New York. pp. 223-233.
- Pillai, M.C., T.S. Shields, R. Yanagimachi, and G.N. Cherr. 1993. Isolation and partial characterization of the sperm motility initiation factor from eggs of the Pacific Herring, *Clupea pallasii*. *Journal of Experimental Zoology*, 265:336-342.
- Cherr, G.N., T.W-M. Fan, M.C. Pillai, T. Shields, and R.M. Higashi. 1993. Electrophoretic separation, characterization, and quantification of biologically active lignin-derived macromolecules. *Analytical Biochemistry*, 214:521-527.
- Garman, G.D., M.C. Pillai, and G.N. Cherr. 1994. Inhibition of cellular events during algal gametophyte development: Effects of select metals and an aqueous petroleum waste. *Aquatic Toxicology*, 28:127-144.
- Pillai, M.C., R. Yanagimachi, and G.N. Cherr. 1994. *In vivo* and *in vitro* initiation of sperm motility using fresh and cryopreserved gametes from the Pacific herring, *Clupea pallasii*. *Journal of Experimental Zoology*, 269:62-68.
- Garman, G.D., M.C. Pillai, L.J. Goff, and G.N. Cherr. 1995. Nuclear events during early development in *Macrocystis pyrifera* gametophytes and the temporal effects of a marine contaminant. *Marine Biology*, 121:355-362.
- Griffin, F.J., C. Vines, M.C. Pillai, R. Yanagimachi, and G.N. Cherr. 1996. Sperm Motility

Gary N. Cherr, Ph.D.
Curriculum Vitae

- Initiation Factor (SMIF) is a minor component of the Pacific herring egg chorion. *Development, Growth, and Differentiation*, 38:193-202.
- Spangenberg, J.M. and G.N. Cherr. 1996. Developmental effects of barium in a marine bivalve (*Mytilus californianus*). *Environmental Toxicology and Chemistry*, 15(10):1769-1774.
- Pillai, M.C., H. Blethrow, R.M. Higashi, C.A. Vines, and G.N. Cherr. 1997. Inhibition of the sea urchin sperm acrosome reaction by a lignin-derived macromolecule. *Aquatic Toxicology*, 37:139-156.
- Garman, G.D., S.L. Anderson, and G.N. Cherr. 1997. Developmental abnormalities and DNA-protein crosslinks in sea urchin embryos exposed to three metals. *Aquatic Toxicology*, 39:247-265.
- Griffin, F.J., M.C. Pillai, C.A. Vines, R. Yanagimachi, and G.N. Cherr. 1998. Effects of salinity on sperm motility, fertilization, and development in the Pacific herring, *Clupea pallasii*. *Biological Bulletin*, 194:25-35. DOI: 10.2307/1542510
- Shamseldin, A.A., J.S. Clegg, C.S. Friedman, G.N. Cherr, and M.C. Pillai. 1997. Induced thermotolerance in the Pacific oyster, *Crassostrea gigas*. *Journal of Shellfish Research*, 16(2):487-491.
- Middaugh, D.P., M.E. Shelton, C.L. McKenney Jr., G.N. Cherr, P.J. Chapman, and L.A. Courtney. 1998. Preliminary observations on responses of embryonic and larval Pacific herring, *Clupea pallasii*, to neutral fraction biodegradation products of weathered Alaska North Slope oil. *Archives Environmental Contamination and Toxicology*, 34:188-196.
- Clegg, J.S., K. R. Uhlinger, S.A. Jackson, G.N. Cherr, E. Rifkin, and C.S. Friedman. 1998. Induced thermotolerance and the heat shock protein-70 family in the Pacific oyster, *Crassostrea gigas*. *Molecular Marine Biology and Biotechnology*, 7(1):21-30.
- Vines, C.A., F.J. Griffin, M.C. Pillai, and G.N. Cherr. 2000. The effects of soluble creosote-derived compounds on development of Pacific herring embryos. *Aquatic Toxicology*. 51 :225-239.
- Huovinen, P.S., G.N. Cherr, A. Oikari, and M.R. Soimauo. 2001. Heat shock protein (HSP70) responses in algae and cladoceran upon exposure to UV radiation. In: Proceedings of the 5th Finnish Conference of Environmental Sciences, T. Lehtonen, J.P. Salminen, and K. Pihlaja, eds. pp225-228.
- Moore, J.D., G.N. Cherr, and C.S. Friedman. 2001. Detection of *Candidatus xenohalictis californiensis*' (Rickettsiales-like prokaryote) inclusions in tissue squashes of abalone (*Haliotis spp.*) gastrointestinal epithelium using a nucleic acid fluorochrome. *Diseases of Aquatic Organisms*, 46(2):147-152.

Gary N. Cherr, Ph.D.
Curriculum Vitae

- Vines, C.A., K. Yoshida, F.J. Griffin, M.C. Pillai, M. Morisawa, R. Yanagimachi and G.N. Cherr. 2002. Motility Initiation in Herring Sperm is Regulated by Reverse Sodium-Calcium Exchange. *Proceedings of the National Academy of Sciences, USA* 99:2026-2031.
- Cherr, G.N. 2002. Can we develop and utilize indicators of ecological integrity to successfully manage ecosystems? In: *Managing for Ecosystem Health*, Third International Congress on Ecosystem Health, C.O. Qualset, D.J. Rapport, D. Ralston and B. Lasley, eds. CRC Press, in press. pp227-229.
- Hamdoun, A.M., F.J. Griffin, and G.N. Cherr. 2002. Tolerance to Biodegraded Crude Oil in Marine Invertebrate embryos and larvae is associated with expression of a multixenobiotic resistance transporter. *Aquatic Toxicology*, 61:127-140.
- Morisawa, S. and G.N. Cherr. 2002. Acrosome reaction in spermatozoa from hagfish (Agnatha) *Eptatretus burgeri* and *E. stouti*: Acrosomal exocytosis and the identification of filamentous actin. *Development, Growth and Differentiation*, 44:337-344.
- Pillai, M.C., C.A. Vines, A.H. Wikramanayake and G.N. Cherr. 2003. Polycyclic aromatic hydrocarbons disrupt axial development in sea urchin embryos through a Beta-Catenin dependent pathway. *Toxicology*, 186: 93-108.
- Hamdoun, A.M., Cheney, D.P., and G.N. Cherr. 2003. Phenotypic plasticity of HSP70 and HSP70 gene expression in the Pacific oyster (*Crassostrea gigas*): Implications for thermal limits and induction of thermal tolerance. *Biological Bulletin*, 205:160-169.
- Griffin, F.J., M.R. Brenner, H.M. Brown, E.H. Smith, C.A. Vines, and G.N. Cherr. 2004. Survival of Pacific herring larvae is a function of external salinity. In: *Larval Fish Ecology in the San Francisco Estuary and Watershed*, *American Fisheries Society Symposium*, 39:37-46.
- Watters, D.L., H.M. Brown, F.J. Griffin, E.J. Larson, and G.N. Cherr. 2004. Pacific Herring spawning grounds in San Francisco Bay: 1973- 2000. In: *Larval Fish Ecology in the San Francisco Estuary and Watershed*, *American Fisheries Society Symposium*, 39:1-9.
- Brown, H.M., A. Briden, T. Stokell, F.J. Griffin, and G.N. Cherr. 2004. Thermotolerance and Hsp70 Profiles in Adult and Embryonic California Native Oysters, *Ostrea conchaphila* (Carpenter, 1857). *Journal of Shellfish Research*, 23(1): 135-141.
- Hamdoun, A.M., G.N. Cherr, T.A. Roepke, and D. Epel. 2004. Activation of multidrug efflux transporter activity at fertilization in sea urchin embryos (*Strongylocentrotus purpuratus*). *Developmental Biology*, 276:452-462.
- Roepke, T.A., M.J. Snyder, and G.N. Cherr. 2005. Estradiol and endocrine disrupting compounds adversely affect development of sea urchin embryos at environmentally relevant concentrations. *Aquatic Toxicology*, 71: 155-173.

Gary N. Cherr, Ph.D.
Curriculum Vitae

- Rose, W.L., J. Hobbs, R. Nisbet, P.G. Green, G. Cherr, S.A. Anderson. 2005. Validation of Otolith Growth Rate Analysis Using Cadmium-Exposed Larval Topsmelt (*Atherinops affinis*). *Environmental Toxicology and Chemistry*, 24(10):2612-2620.
- Friedman, C.S., H.M. Brown, T.W. Ewing, F.J. Griffin, and G.N. Cherr. 2005. Pilot study of the Olympia oyster *Ostrea conchaphila* in the San Francisco Bay estuary: Description and distribution of diseases. *Diseases of Aquatic Organisms*, 65: 1-8.
- Anderson, S.L., G.N. Cherr, S.G. Morgan, C.A. Vines, R.M. Higashi, W.A. Bennett, W.L. Rose, A. Brooks, R.M. Nisbet. 2006. Integrating contaminant responses in indicator saltmarsh species. *Marine Environmental Research*, 62:S317-S321.
- Roepke, T.A., E.S. Chang, and G.N. Cherr. 2006. Maternal exposure to estradiol and endocrine disrupting compounds alters the sensitivity of sea urchin embryos and the expression of an orphan steroid receptor. *Journal of Experimental Zoology*, 305A:830-841.
- Cao, Y., G. N. Cherr, A. L. Cordova, T.W.-M. Fan, R.M. Higashi, M. G. LaMontagne, K.M. Scow, J. Yuan, and P.A. Holden. 2006. Relationships between Sediment Microbial Communities and Pollutants in Two California Salt Marshes. *Microbial Ecology*, 52:619-633.
- Roepke, T.A., A.M. Hamdoun, and G.N. Cherr. 2006. Increase in multidrug transport activity is associated with oocyte maturation in sea stars. *Development, Growth, Differentiation*, 48(9):559-574.
- Rose, W.L., R.M. Nisbet, P.G. Gree, S. Norris, T. Fan, E.H. Smith, G.N. Cherr, and S.L. Anderson. 2006. Using an integrated approach to link biomarker responses and physiological stress to growth impairment of cadmium-exposed larval topsmelt. *Aquatic Toxicology*, 80:298-308.
- Arkush, K.D., G.N. Cherr, and J.S. Clegg. 2008. Induced thermotolerance and tissue Hsc70 in juvenile coho salmon, *Oncorhynchus kisutch*. *Acta Zoologica*, 89:331-338.
- Cherr, G.N., M. Morisawa, C.A. Vines, K. Yoshida, E.H. Smith, T. Matsubara, M.C. Pillai, F.J. Griffin, and R. Yanagimachi. 2008. Role of two egg-derived molecules in sperm motility initiation and fertilization in the Pacific herring (*Clupea pallasii*). *International Journal of Developmental Biology*, 52:743-752.
- Griffin, F.J., E.H. Smith, C.A. Vines, and G.N. Cherr. 2009. Impacts of suspended sediments on fertilization, embryonic development, and early larval life stages of the Pacific Herring, *Clupea pallasii*. *Biological Bulletin*, 216:175-187.
- Keller, A.A., H. Wang, D. Zhou, H. Lenihan, G.N. Cherr, B. Cardinale and R. Miller. 2010. Behavior of metal oxide nanoparticles in natural aqueous matrices. *Environmental Science & Technology*, 44:1962-1967.

Gary N. Cherr, Ph.D.
Curriculum Vitae

- Murata, K., W. Nunomura, Y. Takakuwa, and G.N. Cherr. 2010. Two different unique cardiac isoforms of protein 4.1R in zebrafish, *Dania rerio*, and insights into their cardiac functions as related to their unique structures. *Development, Growth, and Differentiation*. 52:591-602.
- Wedin, R., J. H. Priester, Mielke, R. E., Kraemer, S. Jackson, S., P. K. Stoimenov, G.D Stucky, G.N.Cherr, E. Orias, and P.A. Holden. 2011. Biomagnification of cadmium selenide quantum dots in a simple experimental microbial food chain. *Nature Nanotechnology*, 6:65-71.
- Fairbairn, E.A., Keller, A.A., Madler, L., Zhou, D., Pokhrel, S., and G.N. Cherr. 2011. Metal Oxide Nanomaterials in Seawater: Linking Physical Characteristics with Biological Response in Sea Urchin Development. *Journal of Hazardous Materials*, 192:1565-1571.
- Ford, T.E., A.L.Bass, S.Cheng, G.N.Cherr, B. Cole, E. Fairbairn, J.-D. Gu, R. S. Halbrook, F. E. Loffler, E. L. Madsen, and N.A. McGinn. 2011. EHPC 2010: sharing knowledge on environmental health for risk mitigation. *Ecotoxicology*, 20:937-939.
- Incardona, J.P., C.A. Vines, B.F. Anulacion, D.H. Baldwin, H.L. Day, B.L. French, J.S. Labenia, T.L. Linbo, M.S. Myers, O.P. Olson, C.A. Sloan, S. Sol, F.J. Griffin, K. Menard, S.G. Morgan, J.E. West, T.K. Collier, G.M. Ylitalo, G.N. Cherr, and N.L. Scholz. 2012. Unexpectedly high mortality in Pacific herring embryos exposed to the 2007 *Cosco Busan* oil spill in San Francisco Bay. *Proceedings of the National Academy of Sciences, USA*. 109(2):E51-58.
- Vines, C.A. and G.N. Cherr. 2012. Pollution: Emerging Contaminants. In: *Ecology, Conservation and Restoration of Tidal Afarshes: The San Francisco Estuary*. A. Palaima, cd. University of California Press. pp. 67-86.
- Peterson, C.H., S.S. Anderson, G.N. Cherr, R.F. Ambrose, S. Anghera, S. Bay, M. Blum, R. Condon, T.A. Dean, M. Graham, M. Guzy, S. Hampton, S. Joye, J. Lambrinos, B. Mate, D. Meffert, S. P. Powers, P. Somasundaran, R.B. Spies, C.M. Taylor, R.Tjeerdema, and E.E. Adams. 2012. A Tale of Two Spills: Novel Science and Policy Implications of an Emerging New Oil Spill Model. *BioScience*, 62(5):461-469.
- Brander, S.M., B.J. Cole, and G.N. Cherr. 2012. An approach to detecting estrogenic endocrine disruption via choriogenin expression in an estuarine model fish species. *Ecotoxicology*, 21:1272-1280.
- Griffin, F.J., T. DiMarco, K.L. Menard, J.A. Newman, E.H. Smith, C.A. Vines, and G.N. Cherr. 2012. Impacts of suspended sediments on Pacific herring (*Chupea pallasi*) larval survival and condition. *Estuaries and Coasts*, 35(5):1229-1236.
- Incardona, J.P., C.A. Vines, T.L. Linbo, M.S. Myers, C.A. Sloan, B.F. Anulacion, D. Boyd, T.K. Collier, S.G. Morgan, G.N. Cherr and N.L. Scholz. 2012. Potent phototoxicity of

Gary N. Cherr, Ph.D.
Curriculum Vitae

- marine bunker oil to translucent herring embryos after prolonged weathering. *PLoS ONE*, 7(2): e30116.
- Fairbairn, E.A., J. Bonthius, and G.N. Cherr. 2012. Polycyclic aromatic hydrocarbons and dibutyl phthalate disrupt dorsal-ventral axis determination via the *Wnt1/J-catenin* signaling pathway in zebrafish embryos. *Aquatic Toxicology*, 124-125:188-196.
- Brander, S.M., G. He, K.L. Smalling, M.S. Denison, and G.N. Cherr. 2012. The *in vivo* estrogenic and *in vitro* anti-estrogenic activity of permethrin and bifenthrin. *Environmental Toxicology and Chemistry*, 31(12):2848-2855.
- Holden, P.A., R.M. Nisbet, H.S. Lenihan, R.J. Miller, G.N. Cherr, J.P. Schimel, and J.L. Gardea-Torresdey. 2013. Ecological nanotoxicology: Nanomaterial hazard considerations at the subcellular, population, community, and ecosystems levels. *Accounts of Chemical Research*, 46(3):813-822.
- Hwang, H.-M., R.S. Carr, G.N. Cherr, P.G. Green, E.D. Grosholz, L. Judah, S.G. Morgan, S. Ogle, V.K. Rashbrook, W.L. Rose, S.J. Teh, C.A. Vines, and S.L. Anderson. 2013. Sediment quality assessment in tidal salt marshes in northern California, USA: An evaluation of multiple lines of evidence approach. *Science of the Total Environment*, 454-455:189-198.
- Brander, S.M., R.E. Connon, G. He, J.A. Hobbs, K.L. Smalling, S.J. The, J. W. White, I. Werner, M.S. Denison, and G.N. Cherr. 2013. From 'omics to otoliths: Responses of an estuarine fish to endocrine disrupting compounds across biological scales. *PLoS ONE*, 8(9).
- Cherr, G.N. 2013. Survival of drowning sperm: Do spermatozoa from external fertilizers adapt to differing osmotic environments through the use of aquaporins? *Biol. Reprod.*, 89(2):36, 1-2.
- Murata, K., F.S. Conte, E. Mcinnis, T.H. Fong, and G.N. Cherr. 2014. Identification of the origin and localization of chorion (egg envelope) proteins in an ancient fish, the white sturgeon, *Acipenser transmontanus*. *Biology of Reproduction*, 90(6): 132, 1-12.
- Corsi, I., G.N. Cherr, H.S. Lenihan, J. Labille, M. Hasselov, L. Canesi, F. Dondero, G. Frenzilli, D. Hristozov, V. Pantes, G. Libralato, A. Marcomini, E. Sabbioni, and V. Matranga. 2014. Common strategies and technologies for the ecosafety assessment and design of nanomaterials entering the marine environment. *ACS Nano*, 8(10):9694-9709.
- Renick, V.C., T.W. Anderson, S.G. Morgan, and G.N. Cherr. 2015. Interactive effects of pesticide exposure and habitat structure on behavior and predation of a marine larval fish. 2014. *Ecotoxicology*, 24(2):391-401.

Gary N. Cherr, Ph.D.
Curriculum Vitae

- Wu, B., C. Torres-Duarte, B.J. Cole, and G.N. Cherr. 2015. Copper oxide and zinc oxide nanomaterials act as inhibitors of multidrug resistance transport in sea urchin embryos: Their role as chemosensitizers. *Environmental Science and Technology*, 49:5760-5770.
- Cherr, G.N., C.A. Vines, E.H. Smith, M. Pillai, F.J. Griffin, R. Yanagimachi. 2015. Sperm Motility Initiation in Pacific Herring. *In The Flagellar Mechanics of Spermatozoa: Its Implication in Sperm Guidance*. Bentham Publishing, United Arab Emirates. J. Cosson, ed. pp. 189-204.
- Torres-Duarte, C., S.A. Adeyemi, S. Pokhrel, L. Madler, A.A. Keller, and G.N. Cherr. 2015. Developmental effects of two different copper oxide nanomaterials in sea urchin (*Lytechinus pictus*) embryos. *Nanotoxicology*, 10(6):671-679.
- Yu, J., S. Liu, B. Wu, Z. Shen, G.N. Cherr, X-X. Zhang, and M. Li. 2016. Comparison of cytotoxicity and inhibition of membrane ABC transporters induced by MWCNTs with different length and functional groups. *Environmental Science & Technology*, 50(7):3985-3994.
- Cherr, G.N., E. Fairbairn, and A. Whitehead. 2017. Impacts of Petroleum-Derived Pollutants on Fish Development. *Annual Reviews of Animal Bioscience*, 5:185-203.
- Miller, R., E. Muller, B. Cole, T. Martin, R. Nisbet, G. Bielmyer-Fraser, T. Jarvis, A. Keller, G. Cherr, H. Lenihan. 2017. Photosynthetic: efficiency predicts toxic effects of metal nanomaterials in phytoplankton. *Aquatic Toxicology*, 183:85-93.
- White, J. W., B. Cole, G. N. Cherr, R. Connon, and S. Brander. 2017. Scaling up the individual-level effects of endocrine disruptors: How many males does a population need? *Environmental Science & Technology*, 51:1802-1810.
- Yanagimachi, R., T. Harumi, H. Matsubara, W. Yan, S. Yuan, E. Yamaha, K. Arai, N. Hirohashi, I. Tomoriha, T. Matsubara, T. Andoh, C. Vines, and G. Cherr. 2017. Chemical and physical guidance of fish spermatozoa into the egg through the micropyle. *Biology of Reproduction*, 96(4):780-799.
- Keller, A.A., A.S. Adeleye, J.R. Conway, K.L. Gamer, L. Zhao, G.N. Cherr, J. Hong, J.L. Gardea-Torresdey, H.A. Godwin, S. Hanna, Z. Ji, C. Kaweeteerawat, S. Lin, H. Lenihan, R. Miller, A.E. Nel, S.L. Walker, A.A. Taylor, C. Torres-Duarte, J. Zink, and N. Zuverza-Mena. 2017. Comparative environmental fate and toxicity of copper nanomaterials. *NanoImpact*, 7:28-40.
- Torres-Duarte, C., K.M. Ramos-Torres, R. Rahimoff, and G.N. Cherr. 2017. Stage specific effects of soluble copper and copper oxide nanoparticles during sea urchin embryo development and their relation to intracellular copper uptake. *Aquatic Toxicology*, 189:134-141.

Gary N. Cherr, Ph.D.
Curriculum Vitae

Santillan-Urquiza, E., F. Arteaga-Cardona, C. Torres-Duarte, B. Cole, B. Wu, M.A. Mendez-Rojas, G.N. Cherr. 2017. Facilitation of trace metal uptake in cells by inulin coating of metallic nanoparticles. *Royal Society of Open Science*, 4: 170480.

APPENDIX C

CRITICAL CONDITION SUMMARY REPORT

APPENDIX C

Marina del Rey Harbor Site-Specific Objective Study Critical Condition Summary Report

February 26, 2019

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INTRODUCTION

The USEPA interim guidance for water effect ratio (WER) determination emphasizes the importance of using a sampling design that considers variations in water quality likely to affect the WER (USEPA 1994). EPA has not developed a generalized specific study design for WER studies at large sites such as MdrH. Rather, conceptual guidance for design development is provided:

“Each design has to be formulated individually to fit the specific site. The design should try to take into account the times, locations, and depths at which the extremes of the physical, chemical, and biological conditions occur within the site, which will require detailed information concerning the site.”

Potential sources of variability include seasonality (e.g., summer vs. winter), presence of stormwater discharge, hydrology (tides or depth), and episodic events (e.g., plankton blooms, harbor activities). The relative importance of these factors on WERs in Marina del Rey Harbor (MdrH) is not known.

Included within the combination of various site characteristics is the “critical condition” defined by EPA as: *“...the critical condition, that condition where the copper concentration can be expected to be highest relative to the WER...”* (USEPA 2001). A common goal of all WER studies to identify site-specific objectives that will protect water quality under the critical condition.

Prior monitoring of MdrH for metals shows that elevated copper concentrations occur throughout the harbor. Consistent spatial patterns in MdrH copper are weak, due to the diffuse nature of the primary source (i.e., leaching from thousands of boat hulls distributed among multiple locations). Thus, the critical condition for MdrH can also be defined as that combination of factors resulting in the lowest WER, with the assumption that the location of areas with the highest copper concentration is variable.

This report summarizes the results of field studies to characterize the magnitude and variability in water quality characteristics likely to influence the WER in MdrH. Three site characterization sampling events were conducted in 2018 and included measurements of water quality characteristics known to influence copper bioavailability (e.g., pH, dissolved organic carbon, salinity), as well as copper concentration and toxicity. The results are interpreted with the objective of identifying spatial or temporal patterns that are likely to represent the critical condition for a copper WER in MdrH.

STUDY DESIGN

The site characterization studies were designed to evaluate the spatial and temporal variability in water quality factors considered to be important to determining copper bioavailability in MdRH. Spatial variability was assessed by analyzing water samples from 11 stations located throughout the harbor (Figure 1). These stations represented three different hydrologic regions of the harbor (main channel, front basins, back basins), as well as potential discharges from point (shipyard) and nonpoint sources (Ballona Creek, Oxford Basin, storm drains). Sample depth was also considered, by collecting samples from both near surface and near bottom. Temporal variability was investigated by conducting sampling on three events, with each representing different seasonal conditions: winter-wet weather, spring-dry weather, summer-dry weather. Short-term variability in water characteristics, potentially related to tidal exchange, was investigated during the summer sampling event by collecting multiple samples from the same location at different times of the day. A summary of the sampling events is shown in Table 1.

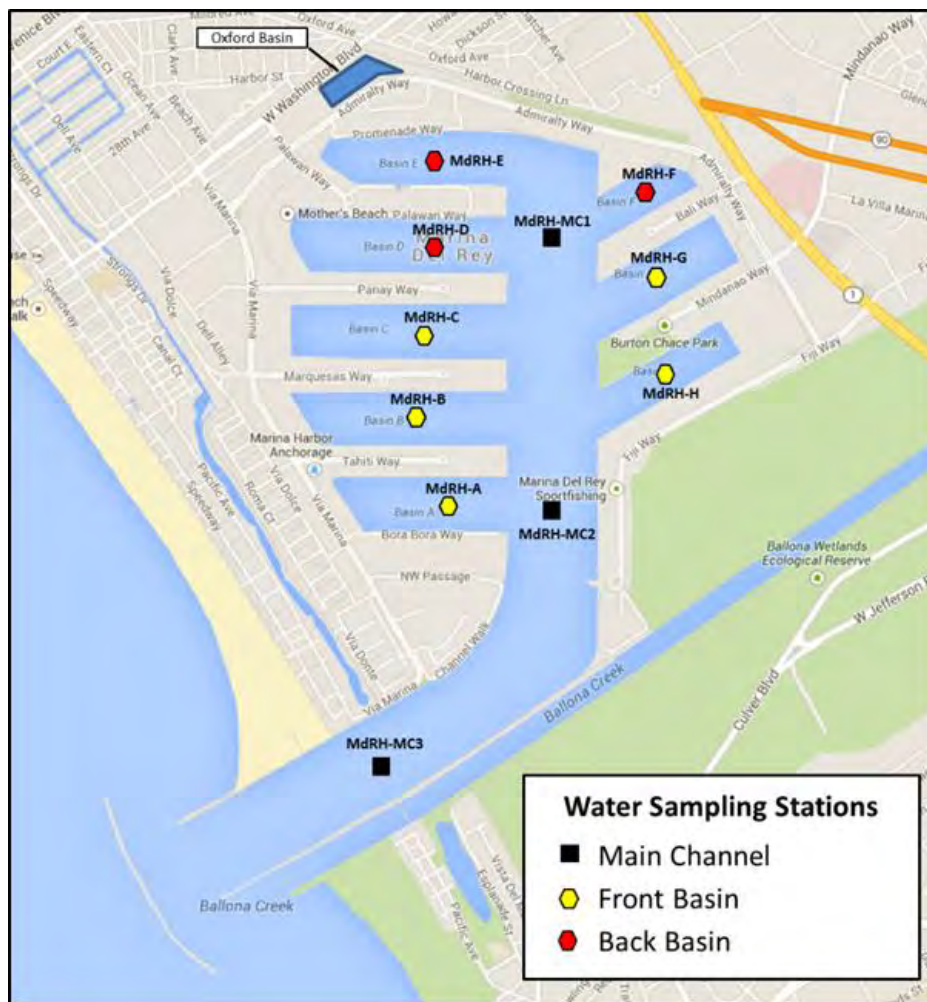


Figure 1. Station locations in Marina del Rey Harbor.

Table 1. Site characterization study design parameters.

Event	Date	Weather	Precipitation (inches)	Sampling depths	Tide Stage		Tide height range relative to MLLW (ft)	Duplicate samples	Stations with repetitive sampling
					Flood	Ebb			
1	3/23/2018	Wet	1.1	B, S	X		0.61 to 2.95	1	0
2	5/21/2018	Dry	0	B, S	X		-0.22 to 3.14	1	0
3	9/10/2018	Dry	0	S	X	X	3.0 to 5.7	2	2

B=bottom depth

S=surface depth

MLLW=mean lower low water

METHODS

Water samples were collected from each of the stations using a peristaltic pump and Teflon-lined tubing (Table 2). Samples from two-depths (1 m above the sediment and 1 m below the water surface) were collected in the first two events. Event 3 samples were collected from the surface only. The specific coordinates listed (Table 2) are from the third sampling event. The timing of each collection event was planned to collect samples from at least two different tide profiles to evaluate potential effects from tide on the critical condition. For all events, sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day. The tidal ranges for each sampling period are presented as a function of time (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>).

Subsamples were immediately filtered through a 0.45 µm polyethersulfone syringe filter for analysis of dissolved metals and dissolved organic carbon (DOC). Additional subsamples were taken for analysis of total metals, toxicity, and chlorophyll. Field measurements of sample pH, dissolved oxygen (DO), temperature, and salinity were made using electrodes.

Dissolved and total concentrations of copper and zinc were measured. Metal analysis was conducted according to USEPA Method 1640 for trace elements in water, using inductively coupled plasma mass spectrometry. In this procedure, trace elements are pre-concentrated based on their reductive precipitation by sodium tetrahydroborate; iron and palladium are added to samples to aid co-precipitation of metal borides and to enhance the precipitation of metals coming out in the elemental form.

Dissolved organic carbon analyses were conducted using USEPA Method 9060a for the analysis of organic carbon by combustion or oxidation.

Toxicity of the water samples was measured with the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The test was conducted under standard conditions specified by USEPA guidance. Toxicity tests were initiated within 48 hours of sample collection. Embryos were preserved for examination at the end of the exposure period. The preserved samples were examined using a microscope to determine the numbers of normal and abnormal surviving embryos. The percent of normal embryos was calculated from the count.

To better evaluate differences in the water quality data collected over time and depth several statistical analyses were applied. One-way analysis of variance (ANOVA) was used to determine

if there were significant differences in DOC, chlorophyll, or dissolved copper concentration by time for all three events. If significant, the Tukey HSD post-hoc test was used to determine the differences. A t-test was also used to determine if there were significant differences by depth for events 1 and 2. Additionally, it was used to determine if the duplicate DOC and chlorophyll data were significantly different from the repeated visit data. Spearman's correlation analysis was also used. Significance was determined if the p value was less than an alpha level of 0.05.

The marine Biotic Ligand Model (BLM) was used to predict the potential for copper toxicity using site water quality data (Arnold et al. 2005). This BLM is currently under review by the USEPA but has not yet been approved for use in water quality criteria development. Water quality data (pH, temperature, DOC, and salinity) from all three sampling events were used in the BLM to calculate a site-specific predicted copper EC50 value for each sample. This value is comparable to an EC50 value for the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). This embryo development test was used to evaluate the toxicity of samples collected from each of the three site characterization events.

Table 2. Station location coordinates within Marina del Rey Harbor.

Station ID	Description	Latitude	Longitude
MdRH-MC1	Main Channel, end	N 33° 58.814'	W 118° 26.886'
MdRH-MC2	Main Channel, middle	N 33° 58.330'	W 118° 26.892'
MdRH-MC3	Main Channel, entrance	N 33° 58.880'	W 118° 27.316'
MdRH-A	Front Basin A, middle	N 33° 58.348'	W 118° 27.194'
MdRH-B	Front Basin B, middle	N 33° 58.504'	W 118° 27.189'
MdRH-C	Front Basin C, middle	N 33° 58.665'	W 118° 27.253'
MdRH-D	Back Basin D, middle	N 33° 58.827'	W 118° 27.243'
MdRH-E	Back Basin E, middle	N 33° 58.977'	W 118° 27.191'
MdRH-F	Back Basin F, middle	N 33° 58.919'	W 118° 26.697'
MdRH-G	Front Basin G, middle	N 33° 58.776'	W 118° 26.626'
MdRH-H	Front Basin H, middle	N 33° 58.584'	W 118° 26.676'

RESULTS

Sampling

Winter-wet weather event

During the winter-wet weather event, the previous 48 hours produced 1.1 inches of rainfall at the Ballona Creek rain gauge, which was above the minimum required rainfall of 0.2 inches specified in the draft work plan. Surrounding areas had rainfall values of 1.41 inches (Santa Monica, north of MdrRH), and 0.75 inches (83rd Street Yard, south of MdrRH). Sampling started at 8:20am and ended at 5:15pm. The first sample (MdrRH-H surface) was taken just before the low tide at 0.7 ft, and the final sample (MdrRH-MC1 bottom) was taken around the high tide of +2.9 ft. The overall tide change for the day was +2.3 ft (Figure 2).

Spring-dry weather event

Sampling started at 8:40am and ended at 2:37pm. The tidal regime for this event was similar to that for the winter sampling. The first sample (MdrRH-MC3 surface) was taken just before the low tide at +0.16 ft, and the final sample (MdrRH-H bottom) was taken around the high tide of +3.14 ft. The overall tide change for the day was +3.36 ft.

Summer-dry weather event

Sampling started at 7:44am and ended at 12:25pm. The first sample (MdrRH-H-1 surface) was taken approximately 3.5 hours after the low tide (-0.35 ft) at +3.0 ft, and the final sample (MdrRH-H-3 surface) was taken approximately two hours after the high tide (+5.75 ft) at +4.63 ft. The overall tide change for the sampling window was +2.75 ft.

Water Quality

All results for water quality, metals concentrations, toxicity, and BLM-based predicted EC50 values for each event are reported in the Appendix. Harbor-wide averages for each sampling event are shown in Table 3.

Salinity measurements showed little change over time and depth. However, there was higher variability in the salinity data during the wet weather event (higher coefficient of variation), which could be due to the freshwater input from rainfall and runoff. Temperature did not vary much by depth but showed a steady increase over time moving from winter through summer. The average pH values were within 0.1 pH units, with similar pH values measured in March and September (7.95) and a slightly reduced pH value (7.84) in May.

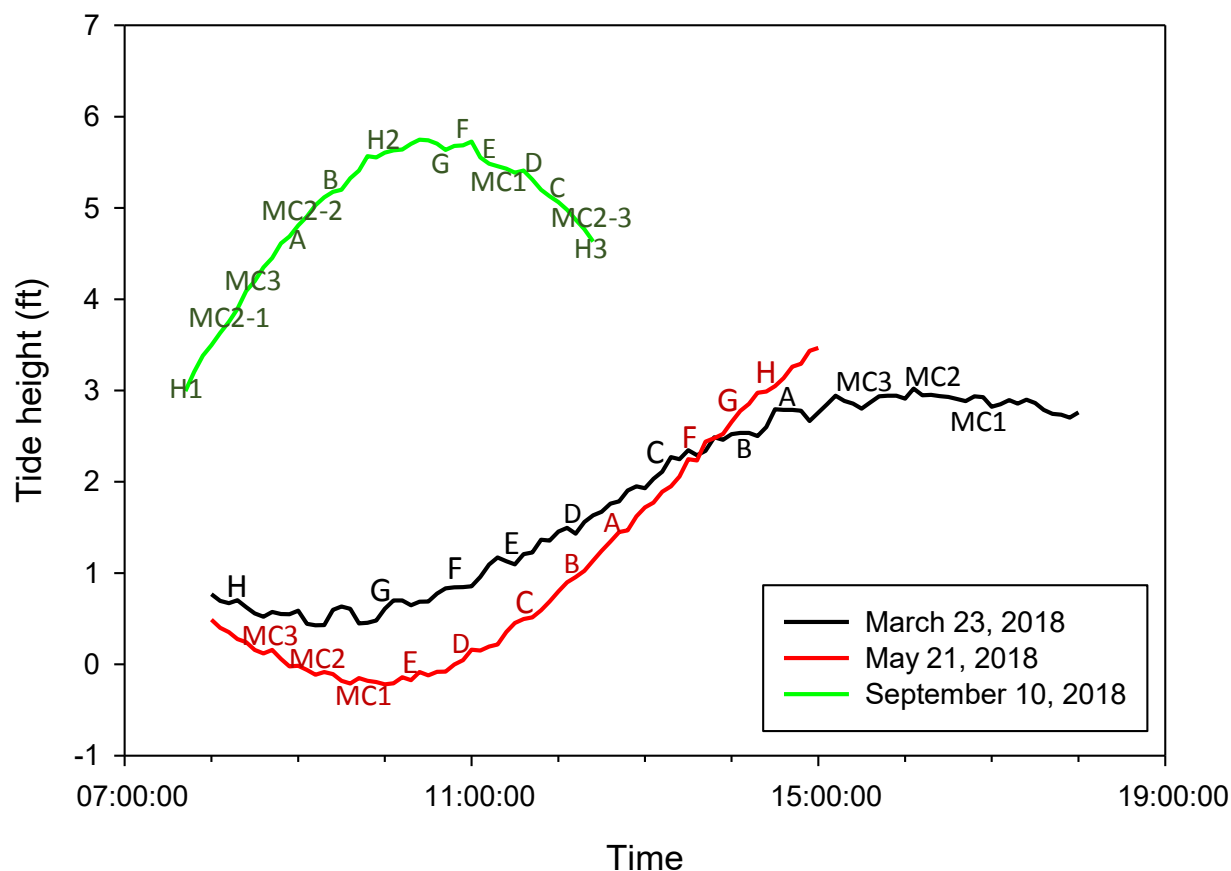


Figure 2. Tide height over the timeframe for each sample collection event: March (black), May (red), and September (green).

DOC and chlorophyll values were the most variable measures by time and depth when compared to temperature, pH, and DO. DOC was higher at most stations in the winter-wet weather event compared to the two dry weather events (Figure 3). The lowest DOC values were frequently in the front basins (A) or in the main channel near the mouth of the harbor (MC3). The location of higher DOC values was more variable, but they frequently occurred in the back basins. This pattern is likely due to water circulation patterns in the Harbor. Chlorophyll showed an increase in concentration from the first event to the second and third events. Chlorophyll concentrations also varied spatially with higher concentrations usually present in the back basins.

Both DOC and chlorophyll were significantly different over time. It was determined that for both DOC and chlorophyll, data from events 2 and 3 (both dry weather events) were different from event 1 (wet weather) but not different from each other. Significant differences by depth were found for DOC and chlorophyll for event 1 (wet weather) but not event 2 (dry weather). Because of the higher variability in time, depth, and space, DOC and chlorophyll may be important determinants of the critical condition.

Harbor average copper concentration was similar among sampling events. Dissolved copper concentrations were not significantly different over time or depth. For all three sampling events,

dissolved copper concentrations were similar among most stations except for the main channel stations in the front basin area (Figure 4). Dissolved copper concentrations at most stations exceeded the current water quality objective of 3.1 µg/L. Stations MdRH-MC2 and -MC3 frequently had lower copper concentrations in surface and/or bottom water samples compared to samples from the rest of the Harbor. Surface concentrations during the winter-wet weather event tended to be higher than bottom concentrations, but these differences were not statistically significant.

Table 3. Harbor-wide average values for MdRH water quality parameters by sampling event and depth. Data are presented as “average (coefficient of variation)”.

Sampling Event	Depth	Dissolved Copper (µg/L)	DOC (mg/L)	Chlorophyll (µg/L)	pH*	Salinity (ppt)	Temperature (°C)
1	Surface	6.64 (33)	1.10 (12)	1.72 (41)	7.93	33.22 (1.7)	16.97 (2.7)
	Bottom	4.70 (54)	0.94 (13)	3.69 (61)	7.95	33.90 (3.1)	16.73 (3.3)
	All	5.71 (44)	1.02 (15)	2.66 (71)	7.94	33.54 (2.6)	16.85 (3.0)
2	Surface	7.02 (17)	0.77 (20)	3.14 (42)	7.84	33.28 (0.38)	19.55 (3.4)
	Bottom	5.64 (47)	0.76 (23)	4.25 (63)	7.84	33.18 (0.18)	19.26 (4.4)
	All	6.36 (33)	0.77 (21)	3.67 (57)	7.84	33.23 (0.33)	19.41 (3.9)
3	Surface	5.71 (33)	0.84 (8.6)	3.10 (41)	7.94	34.07 (0.64)	22.45 (2.6)

*Average is based on hydronium ion (H₃O⁺) concentration and converted back to the log scale. As such, no CV is reported.

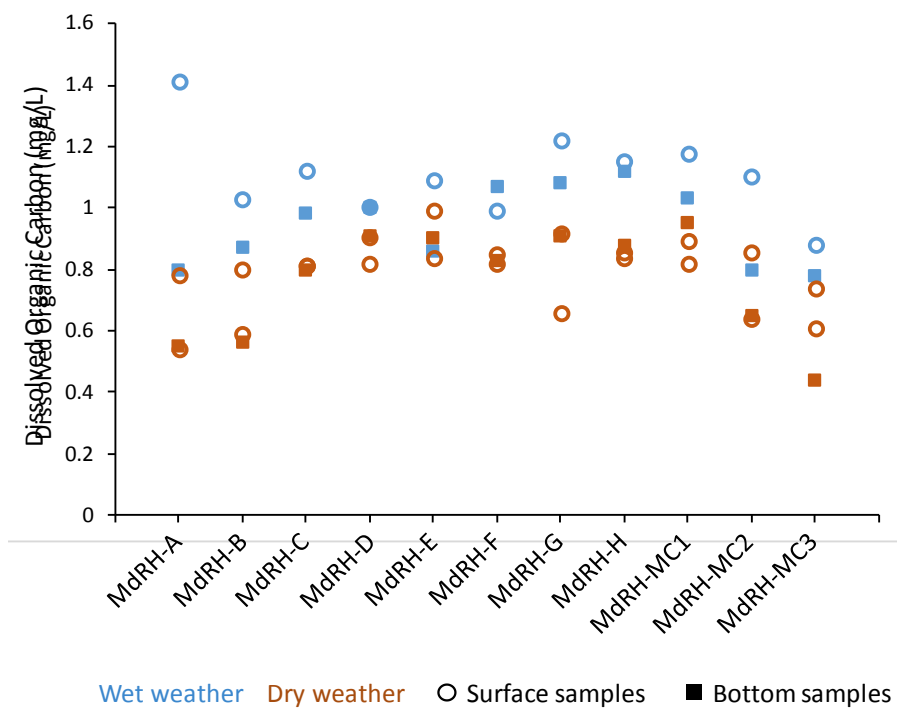


Figure 3. Dissolved organic carbon concentrations (mg/L) at each station by depth (surface=open circles, bottom=closed squares) and weather (wet=blue, dry=orange).

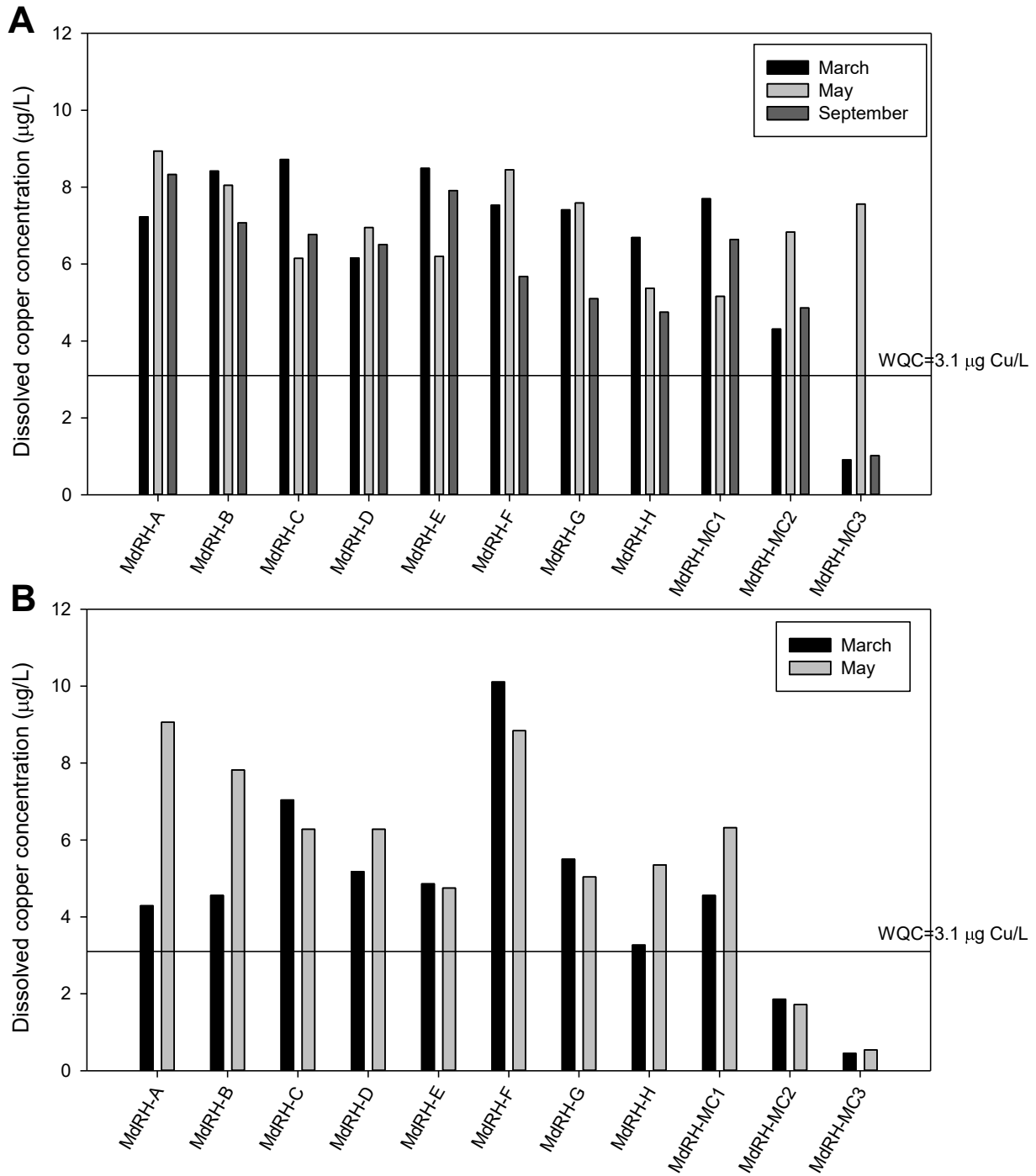


Figure 4. Dissolved copper concentration at each station over time in surface samples (A) and bottom samples (B).

Relationships Among Water Quality Parameters

Correlation analysis was performed for each sampling event to identify relationships between DOC (controlling factor for copper bioavailability) and tide height (as a measure of coastal water influx), chlorophyll, or copper. For the winter-wet weather event, no correlations were found for surface water samples. Bottom samples had a significant correlation ($p=0.015$) between tide height and DOC concentration. This is an inverse relationship where a higher tide height is related to lower DOC. This correlation is driven by low DOC in two of the main channel stations which were both sampled at high tide. Although this result is statistically significant, this depth-related trend may be an artifact of the station sampling sequence. The main channel stations, expected to have relatively low DOC due to greater mixing with offshore water, were sampled at the end of the day (highest tide height).

For the spring-dry weather event, there was no correlation between DOC and tide height. Surface samples had two significant correlations: a correlation ($p=0.031$) between dissolved copper and DOC concentration, and a correlation ($p=0.011$) between DOC concentration and chlorophyll concentration. The first is an inverse relationship where a higher DOC concentration is related to lower copper concentration, and the second is a direct correlation where a higher DOC concentration is related to a higher chlorophyll concentration. The bottom samples only had one significant direct correlation between DOC concentration and chlorophyll concentration ($p=0.002$).

For the summer-dry weather event, none of the parameters were significantly correlated with DOC. The lack of correlation may have been due to the narrow range of DOC values, as there is a minimal spread of data with which to observe a correlation.

Table 4. Summary of parameter correlations with DOC.

Depth	Parameter	DOC (mg/L)		
		March	May	September
Surface	Chlorophyll (ug/L)	-0.40 (0.19)	0.69 (0.011)*	0.20 (0.43)
	Tide height (ft)	-0.011 (0.96)	-0.37 (0.22)	-0.10 (0.69)
	Diss. Copper (ug/L)	0.32 (0.31)	-0.62 (0.031)*	0.41 (0.15)
Bottom	Chlorophyll (ug/L)	0.036 (0.90)	0.79 (0.002)*	
	Tide height (ft)	-0.70 (0.015)*	-0.077 (0.80)	
	Diss. Copper (ug/L)	0.50 (0.11)	0.011 (0.97)	

Data is presented as "correlation coefficient (p Value)". A negative correlation coefficient signifies an inverse relationship. *Denotes significance.

Short-term variability in water quality associated with tide height was investigated in the summer sampling event. Stations MdrRH-H and MdrRH-MC2 were sampled three times over the duration of the sampling event, with a duplicate sample taken during the second visit. Variability in DOC and chlorophyll was compared to results for the duplicate samples (i.e., sampling variability). DOC concentration in the repeated samples was more variable than in the duplicates for both stations (Figure 5). The highest DOC value was measured in the last sample collected, which represented an outgoing tide. The magnitude of the DOC change was relatively small, however. Greater variability in the chlorophyll data was observed for the repeated samples (Figure 6).

However, the range of concentrations among the repeated samples was similar to that for the duplicate, indicating little effect of tide height on the results.

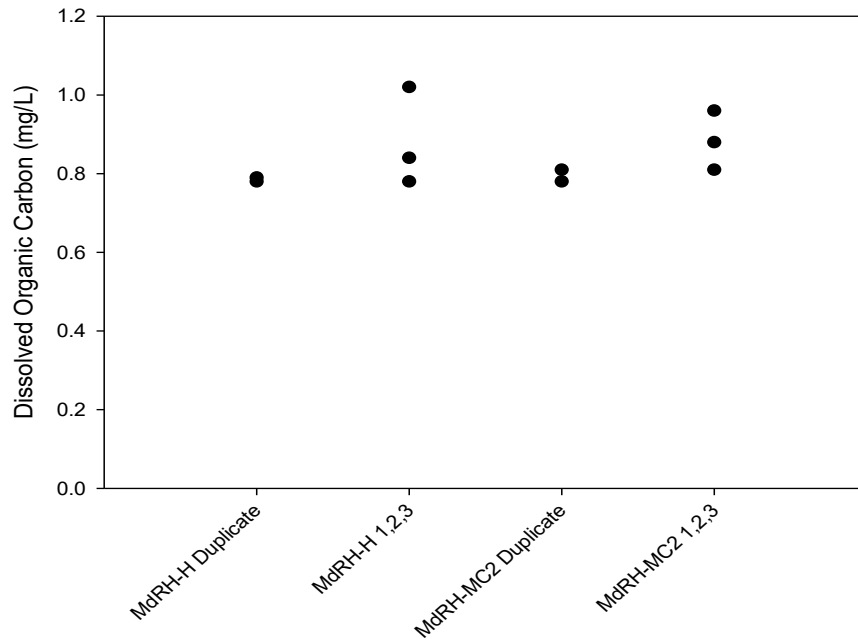


Figure 5. Dissolved organic carbon concentration (mg/L) as a function of duplicate and repeated measurements at stations MdrH-H and -MC2.

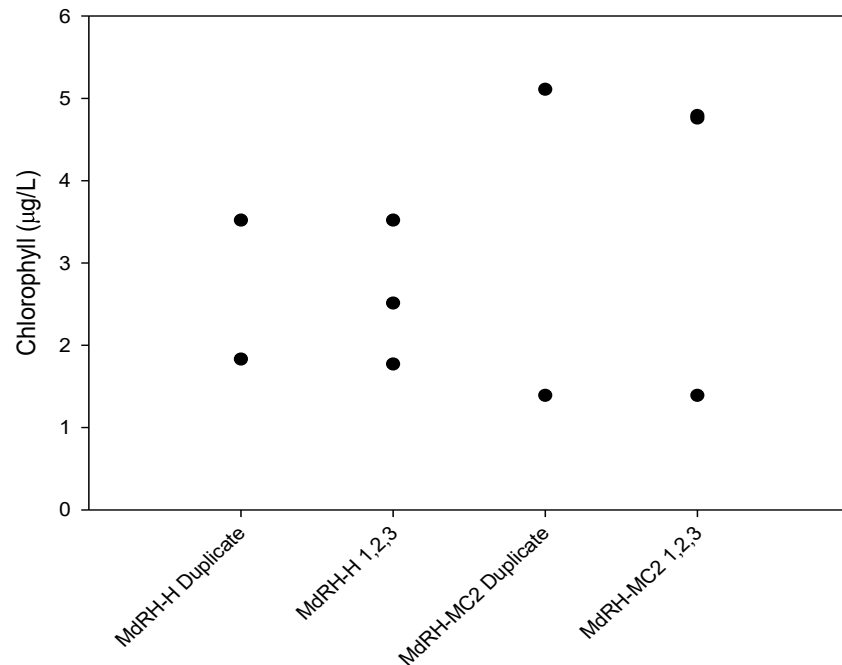


Figure 6. Chlorophyll concentration (mg/L) as a function of duplicate and repeated measurements at stations MdrH-H and -MC2.

Toxicity

Toxicity tests were performed on all samples collected, using the mussel embryo development test. All toxicity results are listed in the Appendix (Tables A1, A2, and A3). These data are used to better characterize MdrH and determine the ambient toxicity in preparation for the WER study, but they are not required to determine the critical condition. The tests for events 1 and 2 met all applicable test performance criteria. The event 3 control (76% normal) fell below the control acceptability threshold of 90% normal. No definitive cause for the low control result was determined but may have been related to general difficulty in obtaining good quality spawning during the warmer summer months. As such, the toxicity results from September are uncertain.

Reference toxicity tests using copper were conducted for each round of testing and all resulting EC50 concentrations fell within two standard deviations of our control chart mean, indicating similar sensitivity of the organisms used in each test. The calculated EC50 value for events 1, 2, and 3 were 8.81 $\mu\text{g Cu/L}$, 8.23 $\mu\text{g Cu/L}$, and 7.33 $\mu\text{g Cu/L}$, respectively. Based on our control chart, these organisms have similar sensitivity to copper as seen in previous tests.

No toxicity was observed for samples from events 1 and 2 (Figure 7). Four stations from event 3 displayed high toxicity: MdrH-B, -E, -F, and -MC1. These results ranged from 12.1-38.7% normal (control-adjusted). However, for all three events, no significant correlation was found between the toxicity test results and the dissolved copper concentrations; there were nontoxic samples from all three events with copper concentrations that were similar to those showing toxicity.

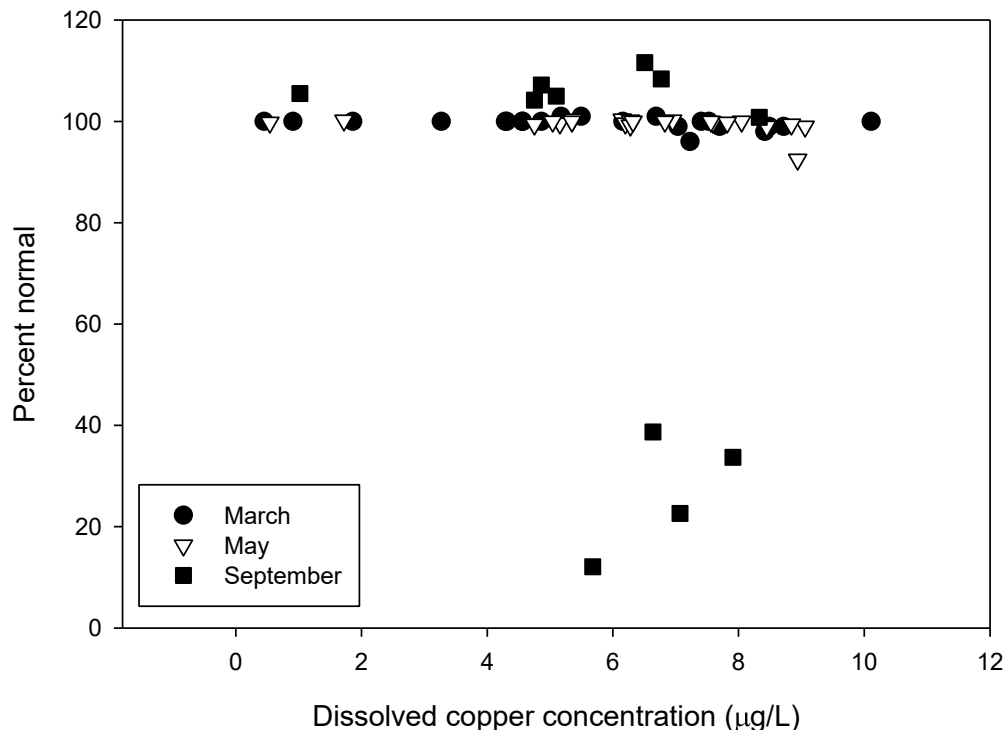


Figure 7. Toxicity as a function of dissolved copper concentration ($\mu\text{g/L}$) for the three sampling events: March (circles), May (triangles), and September (squares).

Biotic-Ligand Model Predictions

The Biotic Ligand Model developed for the draft EPA marine water quality criteria for copper was applied, utilizing the pH, temperature, salinity, and DOC data for each station for all three events. The BLM results provide a predicted acute EC50 concentration based on dissolved copper for *Mytilus galloprovincialis* (same species used in this study). The EC50 value is the concentration at which 50% of the organisms are affected. Thus, it is possible to see some toxicity in water samples with measured concentrations lower than the predicted EC50. The BLM EC50 provides a prediction of toxicity potential for copper, which can be used as another indicator of water quality conditions corresponding to the critical condition. The BLM predicted acute EC50 values were calculated for each station from all three sampling events. Predicted EC50 values ranged from 5.7 to 10.3 µg/L for event 1, 4.0 to 7.3 µg/L for event 2, and 5.8 to 7.6 µg/L for event 3.

Most of the event 1 samples had dissolved copper concentrations less than or equal to the predicted EC50 value (Figure 8A, B). This suggests that low or no toxicity is expected at those stations, which was consistent with the results of the toxicity test. No toxicity was observed for any sample. The results were more variable for event 2, with approximately half of the measured copper values greater than the predicted EC50 (Figure 8C, D). Based on these predictions, about half of the water samples would be expected to show toxicity. However, no toxicity was observed in any sample from event 2. Event 3 results were also variable with six of the measured values less than the predicted EC50 and seven of the measured values greater than the predicted EC50 (Figure 8E). Of the four samples that displayed toxicity, three had measured copper concentrations greater than the predicted EC50. Of the nine non-toxic samples, three of them had measured dissolved copper concentrations greater than the predicted EC50. Overall, 9 out of 13 toxicity test results matched with expectations based on the BLM predicted EC50 value and measured dissolved copper concentrations.

The lack of correspondence between BLM predictions and toxicity results is greater than expected (B. Santore, pers. Comm.), and no explanation is available at this time. Possible factors influencing the results include variations in the sensitivity of the toxicity test that are not identified from the reference toxicant test, toxicity due to materials other than copper, and presence of unmeasured factors influencing bioavailability. Additionally, the nature of the DOC may vary and influence the bioavailability of copper (De Schamphelaere et al., 2004; Nadella et al., 2009).

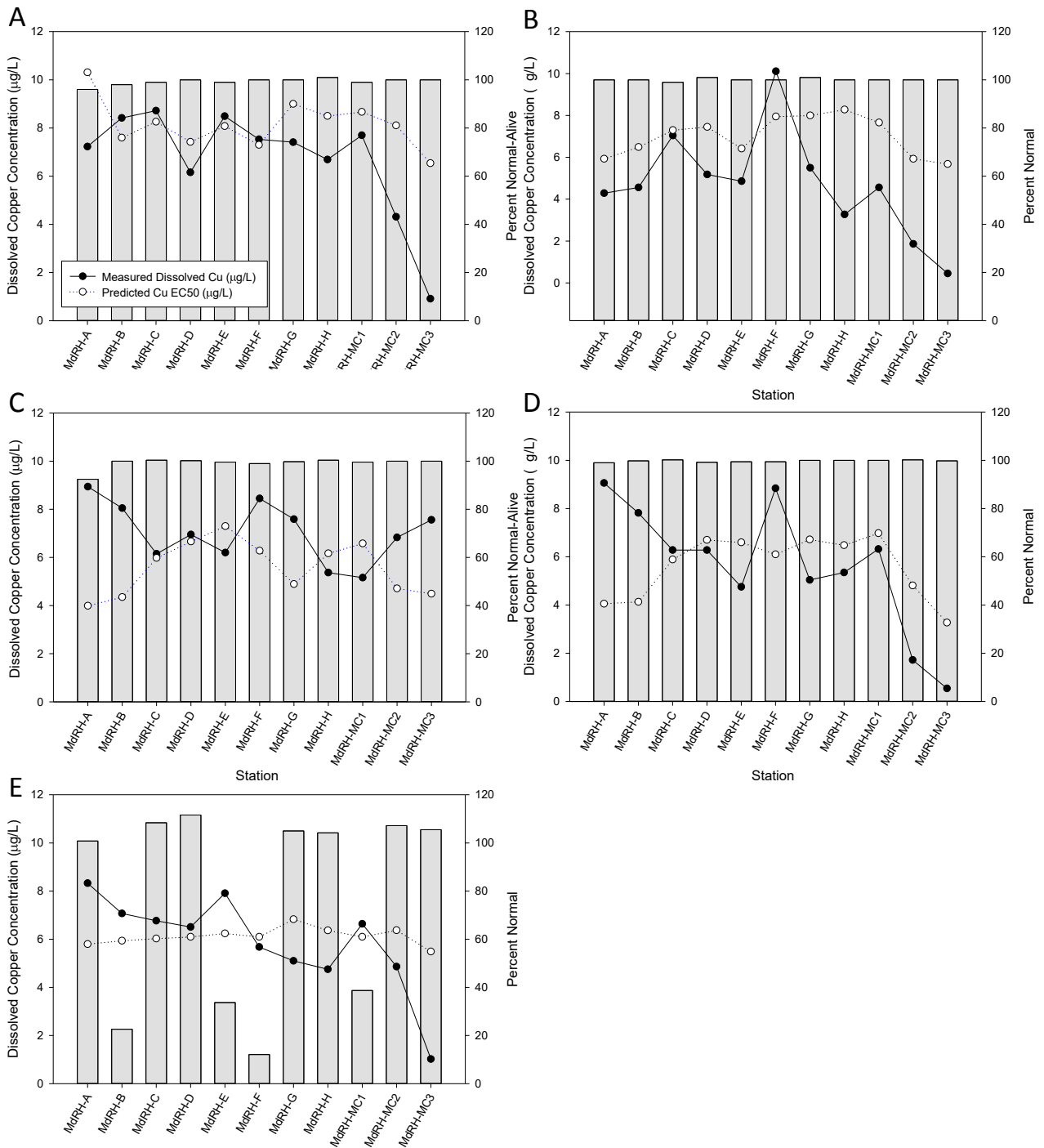


Figure 8. A comparison of the measured (black circles) dissolved copper concentration (µg/L) to the BLM predicted EC50 value (white circles, µg/L) and the toxicity test results (grey bars) for surface and bottom water samples from March (A and B), surface and bottom water samples from May (C and D), and surface water samples from September (E).

SUMMARY

The critical condition is based on when copper bioavailability is expected to be highest, resulting in the greatest toxic potential to resident organisms. This study investigated the influence of nine water quality and other factors on bioavailability (Table 5). Three factors were identified as having the strongest influence on bioavailability: weather (e.g., presence of stormwater runoff), DOC, and location within the harbor. DOC is established in the scientific literature as having a dominant influence on copper bioavailability in marine waters, which supports the conclusion that DOC is a primary factor influencing the critical condition in MdrH. Wet weather conditions that result in stormwater runoff discharges to the harbor are likely to reduce copper bioavailability through an increase in DOC content. However, the nature of DOC input from stormwater may differ from the natural marina DOC which can alter the type of organic matter present between wet and dry events leading to differences in copper bioavailability.

Station location also had a strong influence on DOC content, and thus predicted bioavailability. Stations located near the front region of the harbor generally had the lowest DOC concentrations, possibly due to greater tidal exchange with offshore water having lower DOC. Station location was the factor with most consistent influence on DOC concentration for all three sampling events.

Tide stage and chlorophyll were shown to influence some water quality parameters and potentially bioavailability, but to a minor degree. Correlations between tide height and DOC or copper were occasionally present. However, the magnitude of variation associated with tide stage was similar to that observed among different station locations. Variation in chlorophyll was occasionally associated with DOC variability, likely due to variations in phytoplankton abundance in the harbor. This result indicates that bioavailability of copper may be reduced when phytoplankton blooms are present.

The copper and toxicity measurements made in this study do not directly influence conclusions about the critical condition, as they do not affect bioavailability. However, these parameters are important to developing a study design that includes both the critical condition and conditions representative of harbor locations where impacts are likely to occur. Copper concentrations were similar among most harbor stations located in basins, with the greatest variation apparently associated with seasonal factors. Toxicity to mussels was infrequent in this study, with most of the toxic stations located in the harbor back basins. Thus, a study design that includes back basin locations is likely to represent conditions where biological impacts from dissolved copper are greatest.

In summary, the critical condition (greatest copper bioavailability) is most likely to occur at harbor locations with the lowest DOC. DOC is expected to be lowest during dry weather periods throughout the year and at locations nearest the harbor entrance where water exchange is likely greatest (e.g., main channel and front basins). However, variations in water quality is also expected to occur because of other factors that are poorly understood or difficult to predict. Thus, sampling at multiple locations in the harbor, and over multiple time points, is needed to characterize variations in copper bioavailability.

It is recommended that a study design that includes multiple harbor locations and time points be used for water effect ratio determination in MdRH. Sampling at five locations, representing all three main regions of the harbor, should be sufficient to capture the critical condition for copper variability, as well representing the breadth of harbor conditions for evaluation of a site-specific objective. The recommended station locations are shown in Figure 9.

Table 5. Summary of the effects of the various parameters on the critical condition.

Parameter	Effect on the Critical Condition?		
	Yes	No	Minor
Weather	X		
Tide height			X
Sampling depth		X	
Chlorophyll			X
DOC	X		
Temperature		X	
Salinity*		X	
pH*		X	
Station location	X		

*Data did not vary greatly over time or space. With these minor changes, no effect on critical condition was observed.



Figure 9. Proposed stations for WER analysis.

REFERENCES

- Arnold, W.R., R.C. Santore, and J.S. Cotsifas, 2005. Predicting copper toxicity in estuarine and marine waters using the biotic ligand model. *Marine pollution bulletin*, 50: 1634-1640.
- De Schamphelaere, K.A.C., F.M. Vasconcelos, F.M.G. Tack, H.E. Allen, and C.R. Janssen. 2004. Effect of dissolved organic matter source on acute copper toxicity to *Daphnia magna*. *Environ. Toxicol. Chem.*, 23: 1248-1255.
- Nadella, S.R., J.L. Fitzpatrick, N. Franklin, C. Bucking, D.S. Smith, and C.M. Wood. 2009. Toxicity of Cu, Zn, Ni, and Cd to developing embryos of the blue mussel (*Mytilus trossolus*) and the protective effect of dissolved organic carbon. *Comp. Biochem. Physiol. C*. 149: 340-348.
- United States Environmental Protection Agency (USEPA). 1994. Interim Guidance on the Determination and Use of Water-Effect Ratios for Metals. U.S. Environmental Protection Agency. EPA/823/B-94/001. Office of Science and Technology. Washington, DC. February 1994.
- USEPA, 1995. Short-term methods of estimating the chronic toxicity of effluents and receiving water to west coast marine and estuarine organisms. National Exposure Research Laboratory, Office of Research and Development. Cincinnati, Ohio.
- USEPA. 2001. Streamlined Water-Effect Ratio Procedure for Discharges of Copper. U.S. Environmental Protection Agency. EPA/822/R-01/005. Office of Water. Washington, DC.

ATTACHMENT: SITE CHARACTERIZATION DATA**Table A1. Data collected from the winter wet weather site characterization sampling event on March 23, 2018.**

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
MdRH-A	Surface	1440	2.789	7.76	33.3	16.3	7.8	1.41	1.50	9.36	7.23	55.1	38.5	96.4	10.31
MdRH-A	Bottom	1440	2.789	7.97	33.4	16.5	7.8	0.80	2.01	4.91	4.29	35.1	24.0	100.5	5.93
MdRH-B	Surface	1408	2.536	7.93	32.9	17.5	7.7	1.03	0.88	9.43	8.42	52.2	42.5	98.0	7.60
MdRH-B	Bottom	1408	2.536	7.93	34.7	16.9	8.8	0.87	7.65	9.44	4.56	56.8	25.2	100.2	6.49
MdRH-C	Surface	1313	2.11	7.92	32.8	17.5	7.7	1.12	1.01	8.51	8.72	56.4	45.8	98.8	8.26
MdRH-C	Bottom	1313	2.11	7.94	34.5	17.4	7.8	0.98	1.80	8.24	7.04	49.6	39.3	99.2	7.30
MdRH-D	Surface	1212	1.43	7.90	33.1	17.2	7.8	1.02	2.53	8.51	6.58	56.4	38.3	100.2	7.53
MdRH-D-Dup	Surface	1212	1.43	7.88	33.4	17.5	7.4	0.99	3.12	7.82	5.74	48.6	34.7	100.6	7.32
MdRH-D	Bottom	1250	1.903	7.95	34.6	17.2	7.6	1.00	7.01	8.24	5.18	49.6	33.5	100.5	7.45
MdRH-E	Surface	1132	1.096	7.93	33.7	17.1	7.6	1.09	2.31	10.28	8.49	64.8	55.6	98.7	8.08
MdRH-E	Bottom	1132	1.096	7.87	35.0	17.1	7.0	0.86	4.42	7.10	4.86	52.4	33.6	100.2	6.42
MdRH-F	Surface	1050	0.843	7.98	32.9	16.9	7.4	0.99	1.84	8.89	7.53	48.3	37.4	99.6	7.30
MdRH-F	Bottom	1050	0.843	7.88	34.3	16.9	6.9	1.07	3.88	7.37	10.11	45.9	30.2	99.8	7.95
MdRH-G	Surface	1000	0.607	7.97	32.9	16.7	7.4	1.22	1.07	8.24	7.41	49.8	35.5	99.8	9.00
MdRH-G	Bottom	1000	0.607	7.98	33.7	16.8	7.9	1.08	2.72	6.41	5.50	39.9	28.7	100.7	8.00
MdRH-H	Surface	820	0.702	7.92	33.2	16.8	7.2	1.15	0.93	7.03	6.69	38.8	28.8	100.6	8.50
MdRH-H	Bottom	820	0.702	7.93	33.2	17.2	7.6	1.12	1.07	6.81	3.27	40.4	23.2	100.2	8.28
MdRH-MC1	Surface	1651	2.936	7.98	32.3	17.0	7.9	1.18	2.10	8.66	7.70	52.1	38.8	98.8	8.67
MdRH-MC1	Bottom	1651	2.936	7.98	34.4	16.4	8.2	1.03	5.69	6.97	4.56	45.4	29.7	99.8	7.66
MdRH-MC2	Surface	1620	2.953	8.05	33.5	17.0	8.2	1.10	1.41	5.32	4.31	37.3	24.8	100.0	8.11
MdRH-MC2	Bottom	1620	2.953	7.99	33.8	15.9	8.1	0.80	1.66	3.81	1.86	30.7	11.4	100.4	5.93
MdRH-MC3	Surface	1535	2.871	8.04	34.6	16.1	9.3	0.88	1.88	1.32	0.91	19.8	4.9	100.5	6.54

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
MdRH-MC3	Bottom	1535	2.871	8.07	31.3	15.7	8.8	0.78	2.71	0.83	0.45	17.3	4.1	99.6	5.68
QA samples															
Field Bk*										<0.005	0.03	17.9	0.878		
Travel Bk										<0.005	NA	<0.005	NA		
Tubing Bk										0.14	0.072	13	12.8		

Diss.-Dissolved

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

*The Field blank includes the use of the sample containers and syringe filter system.

Table A2. Data collected from the spring dry weather site characterization sampling event on May 21, 2018.

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
MdRH-A	Surface	1238	1.34	7.83	33.2	19.7	7.4	0.54	1.57	10.9	8.94	34.2	32.0	92.5	3.99
MdRH-A	Bottom	1246	1.47	7.82	33.1	19.3	7.0	0.55	2.05	12.0	9.06	34.0	31.3	99.0	4.05
MdRH-B	Surface	1211	0.96	7.83	33.1*	20.3	7.3	0.59	1.85	9.94	8.05	31.0	30.8	100.0	4.35*
MdRH-B	Bottom	1219	1.02	7.83*	33.1	19.8	7.2	0.56	2.50	9.45	7.82	30.8	29.1	99.8	4.13*
MdRH-C	Surface	1141	0.52	7.86	33.3	19.0	7.3	0.81	2.40	8.41	6.15	30.4	26.6	100.4	5.98
MdRH-C	Bottom	1152	0.69	7.82	33.2	19.7	6.7	0.80	5.38	8.35	6.28	29.5	26.7	100.2	5.89
MdRH-D	Surface	1053	0.05	7.83	33.2	19.5	7.1	1.00	2.87	13.0	6.71	42.3	34.1	100.0	7.36
MdRH-D-Dup	Surface	1105	0.15	7.83*	33.2*	19.5*	7.1*	0.81	5.55	11.1	7.19	39.7	35.3	100.4	5.97*
MdRH-D	Bottom	1115	0.19	7.83*	33.2	19.7	6.5	0.91	3.85	17.0	6.28	46.2	34.4	99.2	6.90*
MdRH-E	Surface	1019	-0.17	7.84	33.3	19.2	6.4	0.99	5.07	12.7	6.20	49.3	40.0	99.6	7.30
MdRH-E	Bottom	1031	-0.12	7.79	33.2	19.4	5.9	0.90	3.60	16.8	4.75	47.8	34.6	99.4	6.60
MdRH-F	Surface	1333	2.24	7.87	33.2	20.9	7.3	0.85	3.79	10.4	8.45	36.7	36.0	99.0	6.28
MdRH-F	Bottom	1339	2.44	7.81	33.1	20.3	6.8	0.83	5.09	10.3	8.84	39.0	40.4	99.4	6.10
MdRH-G	Surface	1400	2.66	7.93	33.3	20.1	7.1	0.66	2.04	9.68	7.59	31.9	30.9	99.8	4.89
MdRH-G	Bottom	1408	2.78	7.86	33.2	19.6	7.9	0.91	10.39	6.91	5.04	21.2	22.3	100.0	6.72
MdRH-H	Surface	1426	2.99	7.79	33.2	19.8	7.1	0.84	3.44	8.79	5.37	30.5	22.4	100.4	6.17
MdRH-H	Bottom	1437	3.14	7.81	33.3	19.4	7.0	0.88	4.21	7.08	5.35	24.2	22.5	100.0	6.48
MdRH-MC1	Surface	0949	-0.18	7.86	33.4	19.3	6.6	0.89	3.88	9.79	5.16	38.7	24.3	99.6	6.58
MdRH-MC1	Bottom	0959	-0.22	7.81	33.2	19.2	6.5	0.95	6.80	8.32	6.32	32.3	30.2	100.0	6.98
MdRH-MC2	Surface	0917	-0.08	7.79	33.5	18.6	6.8	0.64	3.63	8.47	6.83	33.2	28.6	100.0	4.71
MdRH-MC2	Bottom	0928	-0.18	8.01	33.2	18.3	6.9	0.65	2.15	4.21	1.72	11.8	6.79	100.2	4.81
MdRH-MC3	Surface	0840	0.16	7.80	33.5*	18.7	5.4	0.61	1.62	9.10	7.56	29.8	29.1	100.0	4.49*
MdRH-MC3	Bottom	0854	-0.02	7.92	33.2*	17.2	5.6	0.44	0.76	1.48	0.541	3.63	2.14	99.8	3.27*
QA samples															
Field Bk**										<0.005	<0.005	<0.005	0.202		

Station	Depth	Sample Time	Tide (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀
Travel Bk										<0.005	<0.005	<0.005	<0.005		
Tubing Bk										0.118	<0.005	19.5	2.26		

Diss.-Dissolved

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

*Main salinity meter was giving values which seemed very high. A second, uncalibrated unit that was giving more reasonable values was used at the remaining sites. Missing values were completed using the other field measurement (surface or bottom) as there was little observed difference. These values were used in the calculation of the BLM Predicted FAV.

**The Field blank includes the use of the sample containers and syringe filter system.

Table A3. Data collected from the summer dry weather site characterization sampling event on September 10, 2018.

Station	Depth	Sample Time	Tide (ft)	pH*	Salinity* (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Chlorophyll (µg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	Mussel embryo %Normal (Control Adjusted)	BLM Diss. Cu (µg/L) - Predicted Acute EC ₅₀ *
MdRH-A	Surface	0851	4.69	7.90	34.1	22.1	7.1	0.78	1.36	10.1	8.33	39.0	36.9	100.8	5.80
MdRH-B	Surface	0925	5.18	7.90	34.0	22.4	7.8	0.80	4.15	8.45	7.07	32.9	30.8	22.6	5.94
MdRH-C	Surface	1157	5.13	7.90	34.2	23.0	7.1	0.81	3.56	7.71	6.77	32.4	30.1	108.4	6.03
MdRH-D	Surface	1139	5.41	7.89	34.4	23.1	7.1	0.82	4.08	9.37	6.51	39.3	35.5	111.6	6.10
MdRH-E	Surface	1112	5.49	7.88	34.0	23.0	7.0	0.84	2.55	9.80	7.91	51.5	48.9	33.7	6.24
MdRH-F	Surface	1057	5.69	7.92	34.0	23.0	7.0	0.82	2.70	8.90	5.68	30.9	26.9	12.1	6.10
MdRH-G	Surface	1041	5.64	7.91	34.0	22.7	7.7	0.92	4.40	6.67	5.10	25.2	23.2	105.0	6.83
MdRH-H-1	Surface	0744	3.00	7.98	33.9	22.2	6.5	0.84	1.77	NA	NA	NA	NA	NA	6.24
MdRH-H-2	Surface	1001	5.61	7.93	34.1	22.4	7.6	0.78	3.52	6.91	4.87	23.8	21.4	102.6	5.80
MdRH-H-2 Dup	Surface	1010	5.64	8.03	33.8	22.4	7.3	0.79	1.83	6.44	4.63	23.7	22.1	105.8	5.86
MdRH-H-3	Surface	1225	4.63	7.99	34.3	22.6	7.7	1.02	2.51	NA	NA	NA	NA	NA	7.58
MdRH-MC1	Surface	1125	5.43	7.92	34.1	22.9	7.4	0.82	1.68	8.41	6.64	34.7	31.0	38.7	6.10
MdRH-MC2-1	Surface	0812	3.75	7.98	34.6	22.2	7.7	0.88	4.76	NA	NA	NA	NA	NA	6.56
MdRH-MC2-2	Surface	0903	4.91	7.95	34.0	22.1	7.8	0.81	1.39	6.14	4.96	23.4	23.6	104.7	6.02
MdRH-MC2-2 Dup	Surface	0911	5.03	7.94	33.9	22.2	7.7	0.78	5.11	5.85	4.76	24.1	20.9	109.7	5.80
MdRH-MC2-3	Surface	1213	4.87	8.03	34.1	22.7	8.3	0.96	4.79	NA	NA	NA	NA	NA	7.12
MdRH-MC3	Surface	0828	4.20	7.96	33.7	20.6	7.9	0.74	2.53	1.42	1.02	5.68	4.09	105.5	5.49
QA samples															
Field Bk**										<0.005	<0.005	1.34	2.44		
Travel Bk										<0.005	<0.005	<0.0025	<0.0025		
Tubing Bk										0.755	0.376	10.9	18.5		

Diss.-Dissolved DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

NA-Not Analyzed

*Salinity and pH meters were not functional in the field. Data were recorded in the laboratory on September 11, 2018 using water samples collected from the field.

**The Field blank includes the use of the sample containers and syringe filter system.

APPENDIX D

COMMENT RESPONSE TABLE

Commenter No.	Author
1.	Technical Advisory Committee (TAC Summary Recommendations Memo)
2.	Los Angeles Regional Water Quality Control Board (communicated by Shana Rapoport)
3.	Los Angeles Waterkeeper and Heal the Bay (communicated by Arthur S. Pugsley)
4.	Stakeholder (Johntommy Rosas; comments provided in four emails)
5.	Stakeholder (Douglas P. Fay)

The comments tabulated in the following pages are numbered according to comment letter.

No.	Comment	Response	Change
1.1	Charge Question 1: "As with all questions about study design, there is a trade-off between sampling effort and cost. The TAC discussed this question mainly considering roughly the same effort as in the proposed sampling design, that is, about 30 samples, rather than thinking about how additional samples could be added to improve the design. With this in mind, the TAC considered how well the sampling design would provide representative samples in terms of space and time. We propose composite sampling as a general way to increase representativeness without increasing analytical costs."	The TAC has proposed both spatial and temporal compositing to provide a more representative sampling scheme that takes into account spatial variability and variability associated with time (i.e., weather and tidal changes). We agree that this sample compositing will provide a better representation of the condition in the Harbor.	Composite sampling has been added to Sampling Design (Section 2.2.3) and Appendix A (Water Sampling Methods).
1.2	Charge Question 2a: "Zinc is a difficult metal to study, due to the ease with which samples can be inadvertently contaminated. It is essential that trace-metal-clean protocols be used for sample collection and that the Quality Assurance/Quality Control protocols include the appropriate use of certified reference materials (CRMs). The Shelter Island study is a good model for the proper use of CRMs both for copper and DOC."	We agree that trace metal clean protocols will be used. Additionally, we will add a DOC and dissolved copper CRM to the sample analysis and QA/QC methods.	This has been added to 2.2.5 Sample Collection and Processing, 2.4.2 Chemistry Quality Assurance/Quality Control, and Appendix A.
1.3	Charge Question 2b: "The choice of filters here is critical, as inadvertent contamination of the samples with metals or dissolved organic carbon must be avoided. Note that choice of filters may well be different for samples destined for metal analyses and for those that will be analyzed for DOC."	We agree that background contamination by filters should be avoided as well as taken into account through appropriate field blanks for all sample types.	A DOC field blank has been added to Table 9 and Appendix A (Water Sampling Methods).
1.4	Charge Question 2c: "Table 7: Containers for water samples. The glass vials used to collect and store the water samples destined for DOC analysis should be pre-combusted."	We agree. We use pre-combusted amber glass vials for DOC sample collection.	Clarification made in Table 7.
1.5	Charge Question 2d: "The TAC also suggested that the samples collected for DOC analysis could also be subjected to simple spectrophotometric and spectrofluorometric characterization [...] This additional information about the nature of the DOC will be particularly useful in the planned comparisons between the observed toxicity and the BLM-predicted toxicity."	We agree that better characterization of the DOC may be useful for comparisons of observed toxicity and predicted toxicity test results.	Selected samples will be characterized, and the results compared to the toxicity results (Table 6).

No.	Comment	Response	Change
1.6	Charge Question 2: “Among the advantages of using this test organism, the TAC considered its recognized sensitivity to copper, the existence of a wealth of published data on copper – <i>Mytilus</i> early life stage interactions and the precedent that the development of Site-Specific Objectives (SSO) for copper in other coastal environments in California had used this organism and this test. The TAC also suggested that if it proved difficult to induce spawning in laboratory cultures on <i>M. galloprovincialis</i> , other sensitive test organisms could be considered. These include embryos/larvae from <i>Mytilus californianus</i> (California mussel) and <i>Crassostrea gigas</i> (Pacific oyster). “	We agree that the chosen test species (<i>Mytilus galloprovincialis</i>) is sensitive to copper and appropriate for the WER testing. We also agree that similarly sensitive organisms could be substituted if needed.	Clarification made in Toxicity Test Species and Method Selection.
1.7	Charge Question 3: “The TAC is satisfied that the proposed use of the BLM in the work plan, i.e., as a tool to compare measured with predicted toxicities, is the correct manner to proceed. In the view of the TAC, it would be premature to use the marine copper BLM to calculate the SSO for Marina del Rey, i.e., as substitute for the toxicity tests and their use in a WER procedure. However, the use of the BLM to compare predicted and observed toxicities in the unspiked and copper-spiked samples will help answer one of the questions raised by stakeholder participants in the TAC December meeting, namely is copper the only stressor to which <i>M. galloprovincialis</i> is responding in the toxicity tests. Consistent agreement between the predicted and observed toxicities would support the argument that copper is the principal chemical stressor in Marina del Rey waters.”	We agree. Due to several other comments regarding use of the BLM, the workplan will be revised to reflect the TAC’s recommended use of the BLM for comparison purposes only.	Clarifications made in the Introduction.
1.8	Charge Question 4: “The determination of the final WER (fWER) is complicated and more complex than the TAC can fully resolve at this time. [...] The TAC believes that the proposed study plan will provide sufficient data, as identified by the USEPA Interim Guidance, to justify using the geometric mean when calculating the WER. This is the fundamental premise of the sampling design; if we didn’t believe the proposed sampling design was adequate, we would be proposing a different design. However, we also note that the final decision about statistical methods and the final WER determination doesn’t have to be made now. Preliminary analyses of the data after they are collected can inform the final analysis. If it appears the data are not sufficient, then alternate ways of calculating the WER can be determined then.”	We agree. As part of the quarterly TAC meetings and data review process, all stakeholders will be able to interact with the TAC prior to their final data analysis recommendation. This will ensure the final data analysis is appropriate and based on sufficient data.	Clarifications made in Study Design and Methods, Water Effect Ratio Investigation, and Deliverables and Reporting.

No.	Comment	Response	Change
2.1	Will the work plan be completed if the WER appears to be less than 1?	The work plan will be finalized prior to any data collection. If the results of the WER indicate an SSO<1, those results will be presented.	No change made.
2.2	Will the BLM be used to calculate WERs, SSOs or both?	The BLM will only be used as a comparative analysis to the WER results. The SSO will be based on the results of the WER procedure.	No change made.
2.3	Has spiking samples with zinc (as will be done with copper) been considered?	Zinc will not be spiked into the samples as the subject of this SSO study is copper. Since copper is spiked into water from the Harbor, there will be background levels of other metals, including zinc, that will be present in the WER toxicity tests.	No change made.
2.4	The critical condition should be defined based on study results. As there is not yet a U.S. EPA approved version of the saltwater BLM, it is not appropriate to utilize the BLM to define the critical condition in advance of sampling	The BLM does not define the critical condition. We used the BLM during the site characterization events to better characterize the Harbor and highlight certain site-specific parameters that play an important role in copper toxicity.	No change made.
2.5	Please include a minimum of monthly DOC sampling for 1 year in Marina del Rey Harbor to evaluate when during the year DOC is highest and lowest.	Additional DOC monitoring for one year will be done as part of the TMDL monitoring program.	A description of the monthly monitoring plan has been added to the Sampling Design.
2.6	Please state in the Work Plan whether Method 1 or Method 2 from EPA's Interim Guidance are the basis of the study design.	We will be using Method 2.	Clarification made in Study Design and Methods.
2.7	Section 1.2.3: Please discuss previous toxicity testing in Marina del Rey Harbor, including where highest water column toxicity has been observed in the past.	Limited prior toxicity data is available. Some of the data includes the DPR study and recent TMDL monitoring.	Discussion of this topic has been added to the Introduction.
2.8	Section 1.2.3: DPR conducted an investigation of copper levels in California marinas that included BLM application in Marina del Rey Harbor. Please add discussion of this work in the review.	We agree. This is relevant background information.	Discussion of this topic has been added to the Introduction.

No.	Comment	Response	Change
2.9	Section 1.2.3: Please remove discussion of studies that did not result in adoption of an SSO by a Regional Board.	The discussion of previous WER studies provides necessary context and background to this study. While not all of these studies resulted in adoption of an SSO, the information regarding their methods and results helps to inform future work in this field.	No change made.
2.10	Please clarify if preliminary sampling for the BLM will be conducted prior to or in conjunction with sampling in Table 5.	This sampling occurred during the site characterization events in 2018. Preliminary sampling was conducted for a critical condition determination.	Revision made to Study Design and Methods to clarify this.
2.11	Please state EC50 values for <i>M. galloprovincialis</i> and confirm that the relevant endpoint for toxicity tests in laboratory dilution water is close to but not lower than the CCC and CMC as recommended in the 1994 Interim Guidance (pg. 21).	In the 2003 Draft Update of Ambient Water Quality Criteria for Copper, the species mean acute value (SMAV) for <i>Mytilus sp.</i> is 6.19 µg/L, which is the most sensitive species. The CCC (3.1 µg/L) was set to the <i>Mytilus</i> SMAV to protect this commercially important species. The EC50 for our test organism (<i>Mytilus galloprovincialis</i>) in SCCWRP tests is 8.12 µg/L.	This information has been added to the Toxicity Test Species and Method Selection.
2.12	Please identify the first and second most sensitive species to copper in the national copper database and why <i>M. galloprovincialis</i> is preferred.	The most sensitive species is <i>Mytilus sp.</i> with a SMAV of 6.19 µg/L. The second most sensitive species is <i>Mytilus edulis</i> with a SMAV of 21.50 µg/L. This results in a genus mean average (GMAV) of 11.53 for <i>Mytilus</i> . The second most sensitive genus is <i>Crassostrea</i> with a GMAV of 12.60. <i>Mytilus galloprovincialis</i> is the preferred species as it is part of the most sensitive species (<i>Mytilus sp.</i>), as well as the most sensitive genus (<i>Mytilus</i>). Using results based on this species will provide protection for this commercially important species, as intended by the EPA water quality criteria.	This information has been added to the Toxicity Test Species and Method Selection.

No.	Comment	Response	Change
2.13	Please clarify that all individual WER exposures will be initiated within 36 hours of sample collection. This clarification is requested to confirm that tests will not be initiated after 36 hours.	Currently the workplan states “WER exposures will be initiated within 36 hours of sample collection.” (Section 2.1.1 Test Method)	No change made.
2.14	Table 1 – Test conditions in the EPA method indicate salinity should be 30° +/- 2° and the test chamber should be 30mL. Please discuss the rationale for utilizing different test conditions in the study.	Although the EPA test method indicates a salinity of 30 ± 2 ‰, we use 32 ± 2 ‰ to better reflect the salinity in local waters. If we adjusted the salinity down to the EPA range it would require dilution of the sample. Our test chamber volume is 30 mL. The 10 mL listed in the Table reflects the sample volume, which is consistent with the EPA method.	This change has been clarified in the Test Method description.
2.15	Tables 3 and 4 are inconsistent regarding whether samples near the bottom were collected during event 2 or 3.	This is a typo. The first column, row 6 should say “2”, not “3”.	Table 4: Correction made for event number in row 6.
2.16	Table 5 – Please add details in the text regarding the decision process for sample event 6 and how stakeholders will participate in this process.	The decision process for Event 6 will be done in consultation with the TAC during one of the quarterly update meetings. There will also be an opportunity for stakeholder input during those meetings.	A footnote has been added to Table 5 indicating decision process and stakeholder involvement.
2.17	Table 5 – In order to characterize the variability of Marina del Rey Harbor water quality, the Regional Board would like to see three years of sampling.	The TAC has reviewed the proposed workplan and concluded that the current study design is adequate to address temporal and seasonal variations over time (Appendix F, TAC response to charge question 1 and Regional Board question 7)..	No change to study duration made. Text clarified to indicate that the TAC will review preliminary WER results and make a determination as to the need for additional analyses (2.2.3).
2.18	Please add storm drain outlets to Figure 3 as discussed in text.	We agree with this addition.	Figure 4 has been added to the work plan to show storm drain outlets.

No.	Comment	Response	Change
2.19	"Some of the water quality parameters needed for BLM analysis will be measured in the field..." Please clarify when and how other parameters needed for the BLM analysis will be obtained.	DOC is the only other required parameter. It will be collected as a grab sample and analyzed in the laboratory.	Clarified text in Parameters to be Analyzed.
2.20	Please add TSS and turbidity to the parameters that will be analyzed.	These parameters are not relevant to the study as they are not needed for the WER study nor are they used in the BLM.	No change made.
2.21	Please clarify whether or not sampling near the bottom of the water column is included in the work plan. Please add sample collection at 1 meter depth into the work plan to capture area in the water column most impacted by discharge from boat hulls.	Samples will only be collected 1 m below the water surface.	Clarified in Sampling Design.
2.22	Please clarify whether filtering of samples collected in the field for use in toxicity tests will occur in the field or in the laboratory.	Filtration of DOC and dissolved metals samples will be performed in the field. Per recommendation by the TAC, toxicity test samples will be filtered in the laboratory prior to spiking with copper to remove any organisms that may interfere with the test.	Text added for clarification in Sample Collection and Processing.
2.23	Please clarify the toxicity testing procedures. This paragraph indicates there will be no dilution or spiking; however, the draft work plan includes spiking of samples with copper.	We agree. The toxicity test methods were based on the standard test but were inaccurate for the WER study design. The revisions to this text will reflect the accurate methods described in more detail in Section 2.1.1 Test Method.	Text revised in Analysis Methods.
2.24	Please utilize the version of the BLM and reference material included in U.S. EPA's 2016 Draft Aquatic Life Ambient Estuarine/Marine Water Criteria for Copper. The 2012 document cited in the Work Plan does not appear to be included in the 2016 draft criteria.	The reference will be updated.	Reference revised in the "Biotic Ligand Model Analyses" and "References" sections.
2.25	Please increase field QA samples to two field blanks and two field duplicates per sampling event, collected at dispersed times during the sample event.	The number of blanks used for this study (one of each type per sample batch) is consistent with standard practice.	No change made.

No.	Comment	Response	Change
2.26	Please clarify the procedure for spiking samples with copper. How will samples with no effect be obtained for sites where toxicity is exhibited in the site water?	We agree this needs clarification. The laboratory control water will range from no effect to complete inhibition of normal development. The field samples will be spiked with the same range of copper concentrations and the results will be recorded. It is not possible to know the level of toxicity in field samples prior to testing. As such, the resulting toxicity test data will be reviewed to determine if the level of ambient toxicity in any given field sample is too high to provide a useable WER value for that sample.	Revision made to “Water-effect Ratio Testing” section.
2.27	The Regional Board would like verification of dissolved copper in all toxicity treatments and total copper in at least some of the toxicity treatments. This change should be made to Pg. 11, paragraph 5 as well.	We agree. One replicate of all treatments will be analyzed for total and dissolved copper.	Revisions made to clarify this in both Water-effect Ratio Testing and Toxicity test species and method selection.
2.28	For what analyses will recovery surrogates be utilized for QC rather than reference materials?	Per the TAC’s recommendation, reference materials for DOC and copper will be analyzed.	Clarification made to Chemistry Quality Assurance/Quality Control.
2.29	Please include the criteria and statistical methods that will be used to evaluate sWER sample size precision in the Final Work Plan.	The TAC will provide a recommendation on this data analysis during the data review process. Additionally, we will calculate the coefficient of variation and 95% confidence intervals for the sWER results.	Clarification made to text in the Water-Effect Ratio Investigation.
2.30	Please include submittal of data to CEDEN as part of data management.	Data will be provided in CEDEN format and forwarded to LA County for submission to the CEDEN system.	This has been clarified in Deliverables and Reporting.

No.	Comment	Response	Change
2.31	Please include randomization sheets in study documentation and toxicity data quality review	These are included in the umbrella term “laboratory bench sheets”; however, we have included text for clarity.	Toxicity test randomization sheets have been included in the study documentation and toxicity data quality review.
2.32	Public Participation: Please clarify the recipients of each of the reports. Do the draft and final reports discussed in paragraph 3 apply to all task and study reports?	The draft and final report discussed in paragraph 3 refers to the Site-specific Objective Study Report only. Draft results will be provided to the TAC and available to stakeholders as part of the periodic consultation meetings.	Clarification provided in Deliverables and Reporting.
2.33	Public Participation: Please detail how potential decisions and/or changes to the work plan will be communicated (i.e. TBD information for sample event #6, whether or not data indicates the need for additional samples).	Discussion of data, potential changes to the workplan/methods, and any potential decisions will be made during the quarterly meetings with TAC. These meetings will be open to stakeholders.	Clarification provided in Deliverables and Reporting.
2.34	Please change public comment periods from “30 days” to “a minimum of 30 days” to allow for potential requests for additional time to review documents.	We will make the suggested text revision.	Revision made to “Public Participation Plan” section.
2.35	Table 11 – Please clarify whether or not all TAC meetings/calls listed will be open to the public.	Yes, the TAC meetings/calls listed in Table 10 under Project Schedule will be open to stakeholders.	Clarification provided in a footnote for Table 10.
2.36	Please include in the work plan a discussion of whether or not a translator may be used in the study to convert dissolved to total copper. If a translator will be used, please describe how the translator will be selected.	Translators will not be needed or used as we will be measuring dissolved copper in the collected samples.	No change made.
2.37	ELAP Certificate #2769 for Physis Environmental Laboratories appears to be an interim accreditation that expired on 8/31/18. Please confirm whether or not Physis Environmental Laboratories is currently accredited by ELAP for analyses they will be performing for this study.	Their ELAP certification has been renewed and expires on 8/31/2019. The lab will maintain current ELAP certification throughout the study period.	No change made.

No.	Comment	Response	Change
2.38	As recommended in the Interim Guidance document, please compare at least some toxicity test results obtained with results obtained in at least one other laboratory. Guidance pg. 8, paragraph 2 – “...it is important to compare at least some results obtained in the laboratory dilution water with results obtained in at least one other laboratory.”	We will include analysis of a split dilution water sample by another laboratory as part of this study.	A description of this comparison has been added to Toxicity Quality Assurance/Quality Control.
2.39	Please include full details of anticipated WER and BLM calculations/modeling in the Work Plan.	Discussion of the BLM-based calculations are provided in the Biotic Ligand Model Analyses section of the workplan. We can provide additional references regarding the model. WER calculations are described in Sections 1.2.1 Water-Effect Ratio and 2.4 Water-Effect Ratio Analysis and Interpretation.	Additional BLM references and description of data analysis and use has been added to Biotic Ligand Model Analyses.
2.40	QAPP – Table B-1 - Please provide a reference for an EPA method referencing data quality objectives for each parameter.	These measurements (pH, DO, temperature, and salinity) are taken in the field using meters with the appropriate probes. They do not have an EPA method; however, we agree the data quality objectives and calibration details should be added to clarify the data quality of these measurements.	Table B-1 has been revised to include data quality objectives and calibration procedures for these measurements.
2.41	QAPP – Pg. B-5, paragraph 1: Modifications in analytical methods must be approved by the TAC.	We agree. Any changes in methods must be approved by the TAC.	Text has been added to the QAPP to reflect this addition.
2.42	QAPP – Please add QA/QC procedures used to evaluate quality/acceptability of seawater from Granite Canyon. Are hold times implemented for the seawater?	The acceptability of seawater from Granite Canyon is based on low metals content, low DOC content, no ambient toxicity, and previous acceptance by EPA for use in water quality criteria development. These parameters will all be analyzed in the unspiked control. No specific hold time will be implemented; however, we will minimize and document holding times. We will use recently collected water for each test.	A description of these procedures has been added to Laboratory Quality Control in the QAPP.

No.	Comment	Response	Change
2.43	QAPP – Please add a description of personnel training to the QAPP.	We agree. A description of personnel training will be added for the field and laboratory components of this project.	A section on Personnel Training has been added to the QAPP (Appendix B).
2.44	QAPP – Please include a page for signatures of those certifying the adequacy of the QAPP.	We agree a signature page is needed.	A signature page has been added to the QAPP.
3.1	III. General Comments, Section A, Page 3: “The Regional Board should ensure that the approval of the MDR Draft Work Plan does not foreclose analysis of reasonable alternatives to a Copper WER.”	This is a comment directed to the Regional Board.	No change made.
3.2	III. General Comments, Section B, Page 4, Paragraph 1: “Other SSO and WER studies can be illuminating but should not be considered to create binding precedent on the methodology of the MDR Harbor SSO study.”	We agree. These prior SSO studies provide examples of this process but are not directing the methodology proposed in this workplan.	No change made.
3.3	III. General Comments, Section B, Page 4, Paragraph 2: “We strongly urge the MDR Harbor SSO study authors as well as the Regional Board to make source control, particularly control of copper anti-fouling paint, a much higher priority for the MDR Harbor SSO study.”	These issues will be addressed in the implementation report.	No change made.
3.4	III. General Comments, Section B, Page 4, Paragraph 3: “A clear explanation (at a minimum) of the reasonably foreseeable regulatory effects (or lack thereof) of any MDR Harbor SSOs should be included with the MDR Harbor SSO study itself, given the importance of the anti-degradation policies to the ultimate success of the MDR Harbor SSO study.”	We agree. These issues will be addressed in the implementation report.	No change made.
3.5	III. General Comments, Section B, Page 4, Paragraph 4: “The San Francisco Bay 2007 Proposed BPA and Staff Report relied on dissolved organic carbon (DOC) as a surrogate for toxicity in follow-up monitoring. This might be a defensible or even preferred approach for MDR Harbor, but study authors need to carefully justify any proposed use of that approach in MDR Harbor, rather than relying on the approved methodology of past studies.”	We agree. For this project we will be using toxicity tests and will not use DOC as a surrogate for toxicity.	No change made.

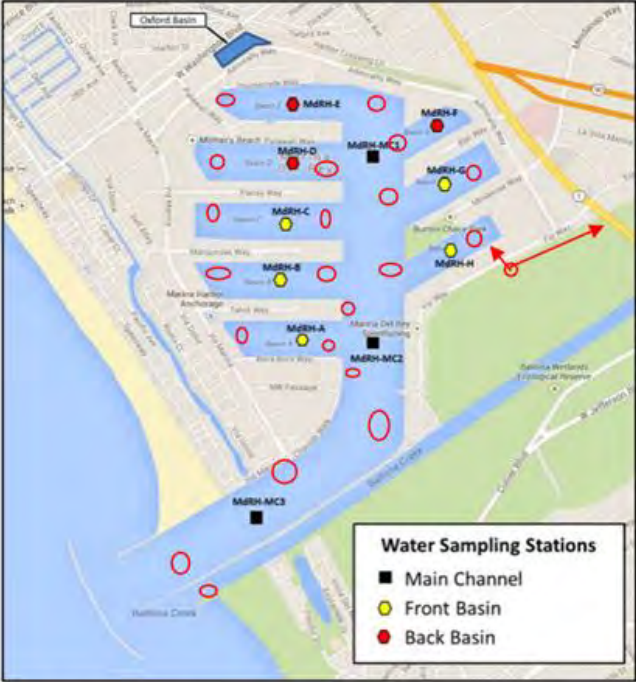
No.	Comment	Response	Change
3.6	III. General Comments, Section B, Page 4, Paragraph 5: "Similarly, the San Francisco Bay 2007 Proposed BPA and Staff Report, as well as the WER study itself, relied on translators, since conversions from total to dissolved copper were necessary in San Francisco. It is unclear to what extent, if any, such translators would be needed or even appropriate in the MDR Harbor SSO study."	Translators will not be used in this study as dissolved copper will be measured.	No change made.
3.7	III. General Comments, Section B, Page 6, Paragraph 1: "LAW and HTB therefore request that if specific methodologies, findings, etc. from previous SSO studies are being imported into the MDR Harbor SSO study, that the study authors include an explanation of the appropriateness in the current context of MDR Harbor, and how the methodology proposed could affect the margin of safety and the protectiveness of the site specific objectives and/or site specific TMDL modifications in MDR Harbor."	We agree. No specific methodologies, findings, etc. will be used from prior SSO studies. These studies are presented in the workplan to provide background and context for the use of SSOs in the state of California.	No change made.
3.8	IV. Comments on the MDR Draft Work Plan, Page 6, Paragraph 3: "We suggest revising the text of the first full paragraph to reflect that site-specific parameters can increase, as well as decrease, toxicity to aquatic organisms (as would be reflected whenever WER < 1.0). In addition, we request a comparison of the margin of safety in the unadjusted WQOs, versus the margin of safety in any WER-adjusted standards."	We agree. We will clarify that the WER can identify an increase or decrease in toxicity based on site-specific parameters. The margin of safety will remain the same as intended by EPA's process for establishing aquatic life criteria (protective of 95% of aquatic life).	Revised to clarify text in the Introduction.
3.9	IV. Comments on the MDR Draft Work Plan, Page 6, Paragraph 4: "We request clarification on why the authors believe use of the BLM is appropriate despite the lack of approval for use of the model in marine waters. Also, we recommend considering revision of the MDR Draft Work Plan to include an alternative study design, if reliance on the BLM turns out to be inappropriate or scientifically less than robust (or if use of the BLM remains unapproved for marine waters as sample WERs are derived)."	We recognize that the BLM is not yet approved for use in marine systems. We will only use the BLM as a comparative analysis to the WER results. The SSO will be based only on the WER results.	Clarified text in the Introduction regarding use of the BLM.
3.10	IV. Comments on the MDR Draft Work Plan, Page 6, Paragraph 5: "LAW and HTB are also concerned that use of the BLM to target the conditions likely to result in the lowest WER (i.e., the critical condition), may not be appropriate if the BLM is not approved for use in marine waters. In any event, it is of the utmost importance that the MDR Harbor SSO study demonstrate that the critical condition has been fully evaluated as part of the study, regardless of whether the BLM is used or not."	The BLM was used to gain more insight during the site characterization study and highlighted DOC as an important site-specific parameter related to predicted copper toxicity. The WER study will still entail six sampling events over a full-year during both wet and dry weather.	Clarified text regarding use of the BLM in the Introduction.

No.	Comment	Response	Change
3.11	IV. Comments on the MDR Draft Work Plan, Page 7, Paragraph 1: "The dispute over the critical condition was one of the single most contentious items in the Los Angeles River Copper WER Study in 2015, so we urge the study authors to carefully justify any claims about the timing of the critical condition, especially if the MDR Harbor SSO study relies of the critical condition relies on a model not approved for use in marine waters."	We agree. The results of the site characterization study suggest the critical condition is when DOC is low. This information helped in the development of the workplan and study design; however, the proposed WER study design includes six sampling events over the course of a year which allows for inclusion of many conditions. Additionally, monthly DOC samples will be analyzed as part of the TMDL monitoring program which will help track any potential fluctuations in the condition of the Harbor.	Clarified text regarding critical condition in the Introduction and Study Design and Methods.
3.12	IV. Comments on the MDR Draft Work Plan, Page 7, Paragraph 2: "Assuming successful resolution of the methodological concerns expressed elsewhere, we agree that the fWERs can be used to adjust both the CCC (chronic) and CMC (acute) WQOs, as well as TMDL adjustments associated with the same location."	We agree. Thank you.	No change made.
3.13	IV. Comments on the MDR Draft Work Plan, Page 7, Paragraph 3-4: "The summary of various other marine WER/SSO studies raises the question of to what extent the MDR Draft Work Plan relies on methodologies in prior studies" and "...the San Diego Regional Board had serious concerns with the design of the Shelter Island Yacht Club WER study (ironically, the WER study that produced the lowest WER values of any of the studies summarized). The MDR Harbor SSO study authors may thus wish to consult with San Diego Regional Board staff for additional information on these apparent concerns."	We did not rely on methods from prior WER/SSO studies. These studies were provided as background and context for WER/SSO studies previously performed in CA.	No change made.
3.14	IV. Comments on the MDR Draft Work Plan, Page 7, Paragraph 5: "...we urge the authors, Regional Board staff, SCCWRP staff, and the Technical Advisory Committee members to consider basing fWERs on the lowest value produced by methodologically correct testing, rather than relying on a geometric mean (or any type of averaging) of several values. This is especially important if the sample WERs (sWERs) show high variability."	Thank you for your suggestion. We have requested the TAC to provide a recommendation regarding this.	The TAC will be consulted to provide a recommendation regarding fWER calculation method (Section 2.5).

No.	Comment	Response	Change
3.15	IV. Comments on the MDR Draft Work Plan, Page 8, Paragraph 1: "We strongly suggest that the study design for the MDR Harbor SSO study include more than three sampling events, and that the number of sampling events in the study (as well as exclusion of data from any sampling event from fWER calculations) be fully justified."	We agree. We will have six sampling events (Table 5).	No change made.
3.16	IV. Comments on the MDR Draft Work Plan, Page 8, Paragraph 2: "We request citations to support the statement that DOC concentration is the primary variable controlling bioavailability of copper in marine systems. Additionally, we request additional evidentiary support that DOC concentration is closely correlated with BLM modeling results, and an explanation whether this DOC/BLM correlation is being used to justify reliance on BLM results despite lack of EPA approval for use of the BLM in marine waters."	We agree that citations are needed. Additionally, the BLM uses DOC, salinity, temperature, and pH as the input variables in the model. Based on our site characterization study, DOC was the most important parameter with regard to the predicted toxicity from the model results. As previously mentioned, the BLM will only be used as a comparison to the WER results.	Citations and clarification provided in Site Characterization.
3.17	IV. Comments on the MDR Draft Work Plan, Page 8, Paragraph 3: "...we recommend that additional DOC monitoring be undertaken prior to WER sampling to confirm the DOC concentration distribution pattern in the study area."	Monthly DOC samples will be collected and analyzed as part of the County's ongoing TMDL monitoring program.	A description of the monthly monitoring plan has been added to the Sampling Design.
3.18	IV. Comments on the MDR Draft Work Plan, Page 8, Paragraph 4: "Similarly, we recommend additional confirmation backed by rigorous data and robust modeling that the critical condition is likely to occur during dry weather in winter or spring."	Based on our site characterization study, the critical condition is likely to occur in lower DOC conditions.	This discussion has been clarified in Site Characterization.
3.19	IV. Comments on the MDR Draft Work Plan, Page 9, Paragraph 1: "Given the probable lowest DOC concentrations in the main channel, we recommend considering adding a second water sampling station in the main channel, in the area of the channel to the east of the terminus of Bora Bora Way, to improve the robustness of the study results."	The TAC has recommended a revised sampling design and station locations.	Study and sampling design revised in accordance with TAC recommendations.
3.20	IV. Comments on the MDR Draft Work Plan, Page 9, Paragraph 2: "We recommend that the study authors consider adding at least a second sampling event in wet conditions."	We've asked the TAC to advise on this matter. The sixth WER sampling event can be used as an additional wet-weather event if recommended.	Sampling design clarified to indicate TAC will provide recommendation regarding additional wet weather sampling (Table 5).

No.	Comment	Response	Change
3.21	IV. Comments on the MDR Draft Work Plan, Page 9, Paragraph 3: “We support the collection of grab samples, and support analyzing zinc concentrations in those samples. However, we ask for greater clarification of the claim that inclusion of zinc in the study will facilitate understanding copper toxicity.” Comment continued through page 10, “In any event, we urge study authors to more fully explain how the MDR Draft Work Plan accounts for synergism, additivity, or reduced efficacy of detoxifying metal-organic complexes when multiple metals are present.”	We agree that this text is unclear. By including zinc in the metals analysis, we hope to gain some insight as to whether zinc is a likely contributor to toxicity. We will not be able to determine a specific relationship between copper and zinc (i.e., synergism, additivity, etc.).	Text clarified in Parameters to be Analyzed.
3.22	IV. Comments on the MDR Draft Work Plan, Page 10, Paragraph 1: “The question of whether the WER sample size and precision allows for a defensible fWER is extremely important. We again urge the study authors to use the lowest WER obtained plus a margin of safety, rather than an average of sWERs, to ensure that the critical condition has been captured, and that the SSOs do not suffer from a potentially serious anti-degradation policy consistency problem as a result.”	The TAC will advise on the final data analysis. An additional margin of safety will not be needed as the water quality criteria is designed to protect 95% of aquatic life. An WER-based SSO is an adjustment of the objective so that the same level of aquatic life protection is attained.	The TAC will be consulted to provide a recommendation regarding fWER calculation method (Section 2.5).
3.23	IV. Comments on the MDR Draft Work Plan, Page 10, Paragraph 2: “We thus strongly encourage revision to this section of the MDR Draft Work Plan, to include a firm commitment to either collect such data until the data set is robust enough to support calculated fWERs, or else to discontinue the process of seeking approval of SSOs if data is insufficient to support calculation of defensible fWERs.”	We agree that sufficient data is necessary to determine an SSO. This workplan includes six sampling events and exceeds the minimum recommended by EPA guidance. The data will be reviewed by the TAC prior to calculation of the fWER.	Text added to clarify this in the Final Water-Effect Ratio Calculation (Section 2.4.3).
3.24	IV. Comments on the MDR Draft Work Plan, Page 10, Paragraph 3: “We strongly recommend formal written responses to comments be prepared, even if the Regional Board believes it does not have a strict legal obligation to prepare such a document as part of its Work Plan review.”	We agree. We have provided written responses to the comments received on the draft workplan via this document, which is an appendix in the final workplan.	Formal comment responses added to the workplan as an appendix.
3.25	IV. Comments on the MDR Draft Work Plan, Page 10, Paragraph 4: “We also request that data collected to support the MDR Harbor SSO study be made available in as close to real time as possible, to further enhance transparency, and to provide for potential feedback to allow identification (and presumably correction) of any problems as early in the process as possible.”	Preliminary data will be made available to stakeholders when it is sent to the TAC for review.	Text added to Deliverables and Reporting to clarify this.
3.26	IV. Comments on the MDR Draft Work Plan, Page 11: Concerns with the June 1994 Environmental Protection Agency Interim Guidance on the Determination and Use of Water Effect Ratios for Metals	The comments provided here are related to the Interim EPA guidance document and do not have any specific suggestions regarding the workplan. These concerns are largely addressed in prior comments.	No change made.

No.	Comment	Response	Change
4.1	Email 1: Several links to a video presentation and resources and an attached Word document with more resource links.	Thank you for the provided resources.	No change made.
4.2	Email 2: "I hope to see sufficient testing and additional testing areas per this citation [USEPA 1994]". This citation recommends sampling multiple stations over a minimum of three sampling events that include different seasons and locations.	We agree. The draft workplan currently adheres to this guidance with a plan to collect samples at five stations with six sampling events over the course of one year.	No change made.
4.3	Email 2: "It's also important to test appx 2 years to get a secondary year to compare with"	The TAC has provided recommendations on the number of sampling events and sampling timeframe. The TAC agrees that the six sampling events distributed over 12 months is an adequate sampling design. The workplan includes 2 years of sampling, 1 year for site characterization and 1 year of WER sampling.	TAC recommendations have been incorporated into the Study Design and Methods section of the workplan.
4.4	Email 2: "The suggested testing areas are not sufficient. There should be an additional 22 stations and 22 locations used for metals analysis."	The TAC has provided recommendations on the number of stations and sampling strategy.	TAC recommendations have been incorporated into the Study Design and Methods section of the workplan.
4.5	Email 2: "Some testing should be near the vessels as well, where the actual discharging occurs."	The goal of this study is to determine the condition of the entire Harbor and its impact on copper bioavailability and toxicity. The TAC has indicated that a representative sample is more important than sampling hot spots.	No change made.
4.6	Email 2: "There should be habitat testing additionally to have the negative impacts on sea life/habitat etc. documented."	This is outside the scope of this project.	No change made.

No.	Comment	Response	Change
4.7	<p>Email 3: Suggested station locations</p>  <p>Figure 3. Candidate sampling stations in Marina del Rey Harbor.</p>	<p>The TAC has provided recommendations on the number of stations and sampling strategy</p>	<p>TAC recommendations have been incorporated into the Study Design and Methods section of the workplan.</p>
4.8	<p>Email 4: "I have reviewed your draft document and I approve of it"</p>	<p>Thank you for your review and approval.</p>	<p>No change made.</p>
5.1	<p>Page 1, Paragraph 4: It is suggested that the County remove the contaminated sediment from the Harbor to improve the water quality.</p>	<p>This is outside the scope of this project. The focus of this work is on toxicity due to copper in the Harbor water, not the sediment.</p>	<p>No change made.</p>

No.	Comment	Response	Change
5.2	Page 2, Paragraph 7: "In the Development of Site-Specific Objectives, it states protection of aquatic life is uncertain. It further states that this study does not account for physical constituents for example, particulate and dissolved organic matter."	These statements from the Draft Workplan refer to the USEPA's Interim Guidance on Determination and Use of Water-Effect Ratios for Metals (USEPA-823-B-94-001, 1994). The current water quality criteria were based on data that did not consider site-specific water quality parameters such as dissolved organic matter. The purpose of this project is to determine what threshold is appropriate and specific to the Harbor to protect aquatic life by considering those site-specific water quality parameters.	No change made.
5.3	Page 2, Paragraph 8: "It does not mention providing the required level of protection for human health."	This is outside the scope of this project. This water quality criterion is only used for protection of aquatic life.	No change made.
5.4	Page 2, Paragraph 11: "The Water-Effect Ratio Study Design – Station Locations excludes Oxford Basin. Why?"	This is outside the scope of this project. The study is evaluating a site-specific objective for the Harbor only. The TAC has reviewed the workplan and provided recommendations regarding sampling station location and number.	No change made.
5.5	Page 2, Paragraph 12: "Absent from the Draft Work Plan is public comment and Q&A at the TAC review meetings and the first public workshop."	The TAC meeting to review the Draft Workplan was public and allowed time for public comments and questions. Additionally, future TAC meetings and workshops will be open to public participation.	Clarification made in the Public Participation Plan.
5.6	Page 2, Paragraph 13: "Under section VII Implementation Report is California Water Code Section 13241 anti-degradation review (as appropriate). If the Draft Work Plan proceeds as proposed degradation of the Harbor will continue and reviewing now is appropriate."	This review will be performed as part of the implementation report.	No change made.

APPENDIX E

TAC AND PUBLIC COMMENTS

Technical Advisory Committee Comment Letter

**TAC Review of Marina del Rey Harbor Site-Specific Objective Study Workplan
February 15, 2019**

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This document presents the consensus comments and recommendations by the Technical Advisory Committee (TAC) regarding the draft workplan for the Marina del Rey Site-Specific Objective Study (October 2018 version). Responses are organized in two sections. The first section addresses charge questions that were provided in conjunction with the December 18 work plan review meeting, held in Marina del Rey on December 18, 2018. The second section includes responses to questions regarding the work plan conveyed by staff of the Los Angeles Regional Water Quality Control Board.

TAC responses to Charge Questions

1. Is the study sampling design (e.g., number of stations, frequency, duration) sufficient to represent the variations in MDRH water quality necessary to determine representative and protective water effect ratios?

As with all questions about study design, there is a trade-off between sampling effort and cost. The TAC discussed this question mainly considering roughly the same effort as in the proposed sampling design, that is, about 30 samples, rather than thinking about how additional samples could be added to improve the design. With this in mind, the TAC considered how well the sampling design would provide representative samples in terms of space and time. We propose composite sampling as a general way to increase representativeness without increasing analytical costs.

Spatial representativeness

The main consideration for spatial representativeness is how conditions might vary across the harbor. Given the limited amount of spatial variability reported in the pilot study, we find the rationale for proposing fewer stations than were sampled in the pilot study is reasonable. Thus, the proposed distribution of sampling stations, with two in basins near the back of the Marina, two in basins near the front of the Marina, and one in the main channel (Figure 1), is appropriate for the purposes of this study.



Figure 1. Proposed stations for WER analysis, from the SSO Draft Final Work Plan.

However, a single location near a particular basin will not capture variability in conditions among different locations in the basin (such as the blind end and middle). Therefore, we recommend that each basin sample consist of samples taken from the end, middle and mouth of the basin that are combined to form a single composite sample to represent the water in that basin.

We suggest that each of these samples be taken 1 m below the surface of the water. Although conditions at the very surface and near the bottom might be different, a sample taken 1 m below the surface of the water will be representative of the majority of the water in the Marina. We do not recommend taking samples close to the docks because these are also microhabitats that do not represent the majority of the water in the Marina.

Temporal representativeness

There are two kinds of temporal changes that seem most likely to influence the results of this sampling program: (1) wet vs. dry weather, and (2) tidal stage.

To capture the temporal variability in WER, the Draft Work Plan proposes six sampling events distributed over 12 months (Table 1). Four of those events were to occur during dry weather, when the critical condition is expected to be present. Two dry weather samples would occur during summer and two would occur during dry weather in winter. One sample would be taken during wet weather in winter. The timing for the sixth sample is not specified ahead of time, but would be “adaptive,” that is, determined based on initial sampling results. In terms of tidal stage, dry weather samples would be split between flood tides and ebb tides.

Table 1. Proposed WER sampling events, from the SSO Draft Final Work Plan.

Event	Tide Stage		Summer	Winter	
			Dry Weather	Dry Weather	Wet Weather
	Flood	Ebb	April – October	November – March	November – March
1	X		X		
2	X			X	
3		X	X		
4		X		X	
5	NA	NA			X
6	TBD	TBD	TBD	TBD	TBD

Notes:

Wet weather sampling is not dependent on tide stage. Sampling event characteristics to be determined based on results of previous events.

NA = not applicable

TBD = to be determined

The TAC agrees with the strategy of distributing samples between dry and wet weather. The Draft Work Plan states that one wet weather sampling event is proposed “to confirm preliminary findings that indicate relatively low copper bioavailability during this time.” It is also our understanding that the sixth sample (indicated as ‘TBD’ in Table 1) is designed to offer the possibility to adjust the sampling plan once WER data have been obtained for both dry and wet sampling periods.

The TAC has recommendations about the wet weather sampling. The goal is to sample after a representative storm, and to sample at a time that represents conditions after storms. Of course, predicting storm timing and intensity is challenging, and for this study it is not necessary to sample during a storm. We recommend that sampling occur one day after a storm. Representative sampling will only occur if the storm is large enough to discharge substantial stormwater into the Marina del Rey. Thus, bigger storms are better than smaller, but we don’t want to miss sampling opportunities by waiting for a large storm that might not occur. Therefore, we recommend sampling after a 0.5” storm. The current storm threshold is 0.2”, but the TAC is concerned that such a small storm may not discharge sufficient stormwater into the Marina, hence the recommendation for a larger storm.

For tidal differences, the proposed sampling plan has samples taken on flood and ebb tides, but makes no mention of spring versus neap tides. The TAC thinks that the magnitude of tidal variation could affect WER, so samples should be taken on spring and neap tides, when tidal changes are maximum and minimum, respectively. It is not necessary to pick the most extreme spring tides since the goal is to acquire representative samples. Rather than having one sample taken on a flood tide and a different sample taken on an ebb tide, if feasible samples should be taken throughout the flood and ebb tide periods of one tidal cycle. To minimize analytical costs, and because we don’t actually care about

differences between flood and ebb tides but rather just want representative samples, these samples can be combined to create a single composite sample for each sampling event. There will be some logistical challenges from occupying a sampling site over a full tidal cycle (through both flood and ebb tides), but if possible to accomplish, this will provide the most representative sample.

2. Are the proposed methods for toxicity and chemistry analyses appropriate and based on sound scientific practice?

The TAC initially had some questions about collection and filtration of the water samples, and about the details of the analysis of dissolved organic carbon (DOC). These questions were submitted to the Southern California Coastal Water Research Project (SCCWRP) scientists before the TAC meeting in December 2017 and were discussed at the meeting. At that time, we understood that SCCWRP was going to take our comments into account in the design of the final work plan. For clarity, the comments and questions that were submitted before the TAC meeting and then discussed are summarized below (the page references are to the work plan, 30 October 2018 version).

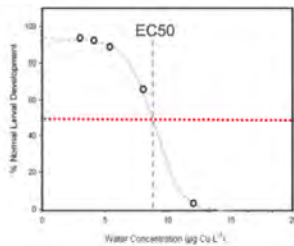
- p.20: “Concentrations of both copper and zinc will be measured, as both of these metals may be elevated in harbors and contribute to ambient toxicity.” Zinc is a difficult metal to study, due to the ease with which samples can be inadvertently contaminated. It is essential that trace-metal-clean protocols be used for sample collection^{1, 2} and that the Quality Assurance/Quality Control protocols include the appropriate use of certified reference materials (CRMs). The Shelter Island study is a good model for the proper use of CRMs both for copper and DOC.³
- p.21: “Samples for measurement of DOC and dissolved metals will be filtered on site within 15 minutes of collection using plastic syringes fitted with 0.45-micron filters.” The choice of filters here is critical^{4, 5}, as inadvertent contamination of the samples with metals or dissolved organic carbon must be avoided. Note that choice of filters may well be different for samples destined for metal analyses and for those that will be analyzed for DOC.
- p.22, Table 7: Containers for water samples. The glass vials used to collect and store the water samples destined for DOC analysis should be pre-combusted.

The TAC also suggested that the samples collected for DOC analysis could also be subjected to simple spectrophotometric and spectrofluorometric characterization. Such analyses require only small sample volumes and it should not be difficult to access the necessary equipment (i.e., a UV-visible spectrophotometer and an excitation-emission fluorimeter).⁶⁻⁸ This additional information about the nature of the DOC will be particularly useful in the planned comparisons between the observed toxicity and the BLM-predicted toxicity.

With respect to the planned toxicity tests, the work plan refers to the SCCWRP Toxicology Laboratory, Standard Operating Procedure for Mussel Embryo Development Test and states, “This test is based on methods in the EPA’s Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms (EPA/600/R-95/136).” The TAC discussed this test and the choice of test organism (*Mytilus galloprovincialis*). The toxicity test assesses mortality of embryos/larvae and at low concentrations, focuses on subtle larval shell morphology. It is well known that mollusc embryos/larvae are exquisitely sensitive to metals. Among the advantages of using this test organism, the TAC considered its recognized sensitivity to copper, the existence of a wealth of published data on copper – *Mytilus* early life stage interactions and the precedent that the development

of Site Specific Objectives (SSO) for copper in other coastal environments in California had used this organism and this test. The TAC also suggested that if it proved difficult to induce spawning in laboratory cultures on *M. galloprovincialis*, other sensitive test organisms could be considered. These include embryos/larvae from *Mytilus californianus* (California mussel) and *Crassostrea gigas* (Pacific oyster). The California mussel is located along the open coast and possibly at the entrance of MDRH, while the Pacific oyster is found on hard substrates throughout the MDRH. The embryos/larvae of both species have been used in toxicity tests with metals, including copper, and have been shown to be as sensitive as *Mytilus galloprovincialis*.

The TAC did raise some questions about the WER approach as it would be applied to the Marina del Rey, where there will be an appreciable background level of copper in the test waters collected from the Marina.



In the documentation supplied to the TAC before the December meeting, it was unclear whether the EC₅₀ for the site water would include the background copper concentration or not. In other words, does the EC₅₀ site value include the background copper, or just the added copper?

With reference to the adjacent figure, taken from the work plan, for the unspiked site water the X-axis will start not at 0 but rather at a value of close to 4 or 5 µg copper/L.

The SCCWRP scientists confirmed that the EC₅₀ value would indeed include both the background copper and the added copper.

3. To what degree should the Biotic Ligand Model be used for data analysis and WER development?

The TAC is satisfied that the proposed use of the BLM in the work plan, i.e., as a tool to compare measured with predicted toxicities, is the correct manner to proceed. In the view of the TAC, it would be premature to use the marine copper BLM to calculate the SSO for Marina del Rey, i.e., as substitute for the toxicity tests and their use in a WER procedure. However, the use of the BLM to compare predicted and observed toxicities in the unspiked and copper-spiked samples will help answer one of the questions raised by stakeholder participants in the TAC December meeting, namely is copper the only stressor to which *M. galloprovincialis* is responding in the toxicity tests. Consistent agreement between the predicted and observed toxicities would support the argument that copper is the principal chemical stressor in Marina del Rey waters.

4. Are the proposed statistical methods for data analysis and final WER determination appropriate?

Questions about the statistical methods proposed for this work have focused on the calculation of the final WER. The Draft Final Work Plan states that "the fWER will be calculated as the geometric mean of the group of single WERs (sWERs) selected for analysis, as recommended in the USEPA (1994) Interim Guidance."

There are other possible ways to calculate the final WER (fWER). The LA Waterkeeper suggests that using the lowest sWER value might be most protective, acknowledging that the USEPA Interim Guidance defines fWERs as geomeans but stating that p. 135 argues for using the lowest value.

The determination of the final WER (fWER) is complicated and more complex than the TAC can fully resolve at this time. We note that the USEPA Interim Guidance has an entire section on “How should an fWER be derived?”, and there are many considerations. Most of the EPA’s discussion revolves around the need to have an adequate number of representative samples, and the guidance also explains a number of different approaches to calculating the fWER under different scenarios. Although the scenarios often don’t relate to the situation at MDRH, the conclusions from the Interim Guidance’s discussion of this issue are relevant. In discussing the calculation of the fWER as an adjusted geometric mean, the Guidance notes that the level of protection *would* be greater if the lowest WER, rather than an adjusted geometric mean, were used as the fWER. However, the Guidance goes on to state that the intended level of protection is provided when the criterion is derived according to the national guidelines, and there is no reason to add a substantial margin of safety and thereby change the intended level of protection if sufficient data are available and it is clear how the data should be used.

The TAC believes that the proposed study plan will provide sufficient data, as identified by the USEPA Interim Guidance, to justify using the geometric mean when calculating the WER. This is the fundamental premise of the sampling design; if we didn’t believe the proposed sampling design was adequate, we would be proposing a different design. However, we also note that the final decision about statistical methods and the final WER determination doesn’t have to be made now. Preliminary analyses of the data after they are collected can inform the final analysis. If it appears the data are not sufficient, then alternate ways of calculating the WER can be determined then.

TAC responses to Water Board Questions

1. Are either the Resident Species or Recalculation procedures potentially appropriate for deriving a site-specific objective for Marina del Rey Harbor?
 - For resident species: there are no threatened or endangered species to be focused on. For recalculation: not that much new data.
2. Selection of Test Species
 - Is *Mytilus galloprovincialis* the most sensitive species? Yes. Bivalve larvae are known to be the most sensitive marine species/life stage for copper, and *Mytilus galloprovincialis* is established as one of the most sensitive of all marine species at the early life stages.
 - Should testing be conducted with multiple species during the study? For determining the WER, use of the most sensitive species that is relevant is all that is necessary.
3. Is the toxicity test proposed appropriate for use in developing a single WER for use in calculating both acute and chronic SSOs in Marina del Rey Harbor?
 - Yes, and it provides good links to earlier SSO work in coastal marine waters in California (San Francisco Bay; Shelter Island Yacht Basin).
4. Are the locations of the sites appropriate for the study? Do the sites capture the variability in Marina del Rey Harbor?
 - With the proposed modifications to the sampling plan, yes. Recall that the TAC suggested that the study design should integrate across the Marina, to be representative, rather than looking for hotspots.
5. Will all potential sources of variability be sufficiently investigated? Episodic events are mentioned in the background section of the work plan but not currently included in the study design. Would sampling during a planktonic bloom, if one occurs during the study period, enhance study results?
 - While it is impossible to design a short-term study to determine all sources of variability in copper levels or in bioassay responses, the current design focuses on the WER for copper and takes into account seasonal differences in copper bioavailability in wet and dry seasons, salinity, pH, etc.
6. Does the study include a sufficient number of sample sites and samples at each site?
 - The TAC believes that for establishing a WER for MDRH an integrative approach is much more relevant than attempting to determine hotspots of copper in the basins. Hot spot determinations would be appropriate for a very different study design of copper sources. The SSO WER study is focused on DOC and copper bioavailability throughout the Harbor in an integrative manner.
7. Will study design capture a sufficient range of conditions to encompass drought and wet year conditions?
 - If the question is if a one-year study is sufficient, the TAC believes it is. The variation in the revised study design covers dry weather and wet weather, capturing this range within a year should cover dry and wet year conditions. Monitoring of physical and chemical parameters (DOC, copper, pH, salinity, etc.) can be continued after the WER sampling via the long-term monitoring program within in MDRH, but toxicity testing should not be necessary beyond the one year of the proposed study.

8. What is the potential effect of discharge from Oxford Basin on study results? Will study design allow for this evaluation? Would an additional sample site near Oxford Basin and/or a storm drain outlet enhance the study results?
 - This study is not designed to address the Oxford basin directly, however site sampling at MDRH-F which is where Oxford Basin drains during tidal flux will provide data on possible contributions of Oxford outflow to MDRH. If high levels of copper are present at MDRH-F, follow-up sampling at the discharge point of Oxford Basin would be warranted.
9. What potential synergistic effects may affect copper toxicity in Marina del Rey Harbor? Are these sufficiently evaluated in the study design?
 - In the data interpretation phase of the project, the planned use of the marine copper BLM will help identify if factors other than copper are affecting the test species. For example, if the measured toxicity proves to be consistently close to that predicted by the copper-BLM, then the effects of other stressors or toxicants in Marina del Rey waters can probably be discounted. On the other hand, if the measured toxicity is consistently greater than that predicted by the copper-BLM, this would suggest that some factors other than copper may be affecting the test species. Note, however, that the performance of the BLM may also be sensitive to other factors, such as the molecular nature of the dissolved organic carbon present in Marina del Rey waters (see the TAC's response to the original charge question #2). In other words, the BLM results will help reply to this question from the Water Board, but they may not provide an unequivocal answer.
10. Is calculation of a final WER in Marina del Rey Harbor through use of a geomean likely to provide a final WER that provides a level of protection equivalent to that of the California Toxics Rule?
 - Based on WER calculations at other sites (San Francisco and San Diego Bays), the TAC presumes that the geomean approach will provide the level of protection expected. However, this will not be determined until sufficient data are available from the proposed study.
11. How will implementation of sediment TMDLs affect the study and results?
 - There is a sediment toxics TMDL already, but no specific plan. The TAC does not know how to answer this directly, but we presume it would have a very minor effect because the water column copper is more influenced by watershed/hydrology factors and by leaching from antifouling paints than by what is in the sediment. Furthermore, copper associated with sediments would be tightly bound due to sulfide binding, as was indicated in previous studies (S. Bay, personal communication), so suspension of MDRH sediments is unlikely to contribute to water column ionic copper levels.
12. What is the likelihood a WER calculated during the proposed study period will be reflective of conditions in Marina del Rey Harbor upon during and after the implementation of the sediment TMDLs for Marina del Rey Harbor?
 - For questions 11 and 12, it is worth mentioning first of all that no remedial measures are planned for the period during which the work plan will be carried out. If dredging is carried out to remove copper-contaminated sediment, then based on the comprehensive studies performed by the US Army Corps of Engineers in their Dredged

Material Research Program, there should be negligible release of additional dissolved copper to the water column during the dredging operations. Dredging necessarily leads to increases in the concentration of fine particles in the water column and it also promotes the formation of hydrous iron oxides when the ferrous iron present in the sediment pore water is introduced into the oxic water column⁹. In both cases, the copper in the water column will tend to adsorb onto these particles and sink to the bottom of the marina, thus leading to a decrease in the dissolved copper concentration.

13. How might potential electrical discharges into the marina affect copper toxicity and a potential WER?
- The TAC is not clear what this question is asking. If this is related to electrolysis of metals in seawater and release of copper ions, or if the question deals with high voltage from shore-based electrical sources. In either case, the TAC believes that this source of copper in seawater in MDRH would be relatively trivial.

Cited references:

1. Nriagu, J. O.; Lawson, G.; Wong, H. K. T.; Azcue, J. M., A protocol for minimizing contamination in the analysis of trace metals in Great Lakes waters. *J.Great Lakes Res.* **1993**, *19*, 175-182.
2. Cutter, G.; Andersson, P.; Codispoti, L.; Croot, P.; François, R.; Lohan, M. C.; Obata, H.; Rutgers v. d. Loeff, M. *Sampling and sample-handling protocols for GEOTRACES* Alfred Wegener Institute for Polar and Marine Research: Bremerhaven, Germany, **2010**; p 238.
3. Bosse, C.; Rosen, G.; Colvin, M.; Earley, P.; Santore, R.; Rivera-Duarte, I., Copper bioavailability and toxicity to *Mytilus galloprovincialis* in Shelter Island Yacht Basin, San Diego, CA. *Mar. Pollut. Bull.* **2014**, *85*, (1), 225-234.
4. Horowitz, M.; DeMason, D. A.; Fitzgerald, K. K.; Miller, T. L.; Rickert, D. A. *US Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water*; USGS: Reston, VA, USA, **1994**; p 57.
5. Horowitz, A. J.; Lemieux, C.; Lum, K. R.; Garbarino, J. R.; Hall, G. E. M.; Demas, C. R., Problems associated with using filtration to define dissolved trace element concentrations in natural water samples. *Environ. Sci. Technol.* **1996**, *30*, (3), 954-963.
6. Tait, T. N.; Cooper, C. A.; McGeer, J. C.; Wood, C. M.; Smith, D. S., Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environ. Chem.* **2016**, *13*, (3), 496-506.
7. Tait, T. N.; McGeer, J. C.; Smith, D. S., Testing the underlying chemical principles of the Biotic Ligand Model (BLM) to marine copper systems: measuring copper speciation using fluorescence quenching. *Bull. Environ. Contam. Toxicol.* **2017**, *100*, (1), 76-81.
8. US EPA *Determination of Total Organic Carbon and Specific UV Absorbance at 254 nm in Source Water and Drinking Water*; EPA/600/R-05/055; Cincinnati, OH, USA, **2005**; p 56.
9. Jones-Lee, A.; Lee, G. F., Role of iron chemistry in controlling the release of pollutants from resuspended sediments. *Remediation* **2005**, *16*, (1), 33-41.

Los Angeles Regional Water Quality Control Board Comment Letter

**Regional Board Feedback Regarding Draft Work Plan: Marina del Rey Harbor SSO Study
Provided by Los Angeles Water Board on December 4, 2018**

Questions for TAC:

- Are either the Resident Species or Recalculation procedures potentially appropriate for deriving a site-specific objective for Marina del Rey Harbor?
- Selection of Test Species
 - Is *Mytilus galloprovincialis* the most sensitive species?
 - Should testing be conducted with multiple species during the study?
- Is the toxicity test proposed appropriate for use in developing a single WER for use in calculating both acute and chronic SSOs in Marina del Rey Harbor?
- Are the locations of the sites appropriate for the study? Do the sites capture the variability in Marina del Rey Harbor?
- Will all potential sources of variability be sufficiently investigated? Episodic events are mentioned in the background section of the work plan but not currently included in the study design. Would sampling during a planktonic bloom, if one occurs during the study period, enhance study results?
- Does the study include a sufficient number of sample sites and samples at each site?
 - The Regional Board would like to see additional sample sites, potentially near areas where organisms aggregate (e.g. dock pilings) and where copper concentrations are highest (e.g. near boats). Consider multiple sample sites within a basin.
- Will study design capture a sufficient range of conditions to encompass drought and wet year conditions?
- What is the potential effect of discharge from Oxford Basin on study results? Will study design allow for this evaluation? Would an additional sample site near Oxford Basin and/or a storm drain outlet enhance the study results?
- What potential synergistic effects may affect copper toxicity in Marina del Rey Harbor? Are these sufficiently evaluated in the study design?
- Is calculation of a final WER in Marina del Rey Harbor through use of a geomean likely to provide a final WER that provides a level of protection equivalent to that of the California Toxics Rule?
- How will implementation of sediment TMDLs affect the study and results?
- What is the likelihood a WER calculated during the proposed study period will be reflective of conditions in Marina del Rey Harbor upon during and after the implementation of the sediment TMDLs for Marina del Rey Harbor?
- How might potential electrical discharges into the marina affect copper toxicity and a potential WER?

Questions regarding Draft Work Plan:

- Will the work plan be completed if the WER appears to be less than 1?
- Pg. 3, paragraph 2 – Will the BLM be used to calculate WERs, SSOs or both?
- Pg. 20, paragraph 4 – Has spiking samples with zinc (as will be done with copper) been considered?

Requested edits to Work Plan:

- The critical condition should be defined based on study results. As there is not yet a U.S. EPA approved version of the saltwater BLM, it is not appropriate to utilize the BLM to define the critical condition in advance of sampling.
- Please include a minimum of monthly DOC sampling for 1 year in Marina del Rey Harbor to evaluate when during the year DOC is highest and lowest.
- Please state in the Work Plan whether Method 1 or Method 2 from EPA's Interim Guidance are the basis of the study design.
- Section 1.2.3
 - Please discuss previous toxicity testing in Marina del Rey Harbor, including where highest water column toxicity has been observed in the past.
 - DPR conducted an investigation of copper levels in California marinas that included BLM application in Marina del Rey Harbor. Please add discussion of this work in the review.
 - Please remove discussion of studies that did not result in adoption of an SSO by a Regional Board.
- Pg. 10, paragraph 1 – Please clarify if preliminary sampling for the BLM will be conducted prior to or in conjunction with sampling in Table 5.
 - Pg. 10, paragraph 4 – Please state EC50 values for *M. galloprovincialis* and confirm that the relevant endpoint for toxicity tests in laboratory dilution water is close to but not lower than the CCC and CMC as recommended in the 1994 Interim Guidance (pg. 21).
- Pg. 11, paragraph 1 – Please identify the first and second most sensitive species to copper in the national copper database and why *M. galloprovincialis* is preferred.
- Pg. 11, paragraph 5 – Please clarify that all individual WER exposures will be initiated within 36 hours of sample collection. This clarification is requested to confirm that tests will not be initiated after 36 hours.
- Pg. 13, Table 1 – Test conditions in the EPA method indicate salinity should be 30‰ +/- 2‰ and the test chamber should be 30mL. Please discuss the rationale for utilizing different test conditions in the study.
- Pg. 17, Table 4 – Tables 3 and 4 are inconsistent regarding whether samples near the bottom were collected during event 2 or 3.
- Pg. 19, Table 5
 - Please add details in the text regarding the decision process for sample event 6 and how stakeholders will participate in this process.
 - In order to characterize the variability of Marina del Rey Harbor water quality, the Regional Board would like to see three years of sampling.
- Pg. 20, paragraph 2 – Please add storm drain outlets to Figure 3 as discussed in text.
- Pg. 20, paragraph 3 – “Some of the water quality parameters needed for BLM analysis will be measured in the field...” Please clarify when and how other parameters needed for the BLM analysis will be obtained.
- Pg. 20, paragraph 3 – Please add TSS and turbidity to the parameters that will be analyzed.
- Pg. 20, paragraph 4 – Please clarify whether or not sampling near the bottom of the water column is included in the work plan. Please add sample collection at 1 meter depth into the work plan to capture area in the water column most impacted by discharge from boat hulls.
- Pg. 21, paragraph 1 – Please clarify whether filtering of samples collected in the field for use in toxicity tests will occur in the field or in the laboratory.
- Pg. 23, paragraph 2 – Please clarify the toxicity testing procedures. This paragraph indicates there will be no dilution or spiking; however, the draft work plan includes spiking of samples with copper.

- Pg. 23, paragraph 3- Please utilize the version of the BLM and reference material included in U.S. EPA's 2016 Draft Aquatic Life Ambient Estuarine/Marine Water Criteria for Copper. The 2012 document cited in the Work Plan does not appear to be included in the 2016 draft criteria.
- Pg. 24, paragraph 2 – Please increase field QA samples to two field blanks and two field duplicates per sampling event, collected at dispersed times during the sample event.
- Pg. 24, paragraph 3 – Please clarify the procedure for spiking samples with copper. How will samples with no effect be obtained for sites where toxicity is exhibited in the site water?
- Pg. 25, paragraph 2 – The Regional Board would like verification of dissolved copper in all toxicity treatments and total copper in at least some of the toxicity treatments. This change should be made to Pg. 11, paragraph 5 as well.
- Pg. 26, paragraph 3 – For what analyses will recovery surrogates be utilized for QC rather than reference materials?
- Pg. 27, paragraph 4 – Please include the criteria and statistical methods that will be used to evaluate sWER sample size precision in the Final Work Plan.
- Pg. 29 – Please include submittal of data to CEDEN as part of data management.
- Pg. 29, paragraph 3 – Please include randomization sheets in study documentation and toxicity data quality review
- Pg. 30, Public Participation
 - Please clarify the recipients of each of the reports. Do the draft and final reports discussed in paragraph 3 apply to all task and study reports?
 - Please detail how potential decisions and/or changes to the work plan will be communicated (i.e. TBD information for sample event #6, whether or not data indicates the need for additional samples).
- Pg. 31, paragraph 1 – Please change public comment periods from “30 days” to “a minimum of 30 days” to allow for potential requests for additional time to review documents.
- Pg. 33, Table 11 – Please clarify whether or not all TAC meetings/calls listed will be open to the public.
- Please include in the work plan a discussion of whether or not a translator may be used in the study to convert dissolved to total copper. If a translator will be used, please describe how the translator will be selected.
- ELAP Certificate #2769 for Physis Environmental Laboratories appears to be an interim accreditation that expired on 8/31/18. Please confirm whether or not Physis Environmental Laboratories is currently accredited by ELAP for analyses they will be performing for this study.
- As recommended in the Interim Guidance document, please compare at least some toxicity test results obtained with results obtained in at least one other laboratory.
 - Guidance pg. 8, paragraph 2 – “...it is important to compare at least some results obtained in the laboratory dilution water with results obtained in at least one other laboratory.”
- Please include full details of anticipated WER and BLM calculations/modeling in the Work Plan.
- QAPP
 - Table B-1 - Please provide a reference for an EPA method referencing data quality objectives for each parameter.
 - Pg. B-5, paragraph 1: Modifications in analytical methods must be approved by the TAC.
 - Please add QA/QC procedures used to evaluate quality/acceptability of seawater from Granite Canyon. Are hold times implemented for the seawater?
 - Please add a description of personnel training to the QAPP.
 - Please include a page for signatures of those certifying the adequacy of the QAPP.

Los Angeles Waterkeeper and Heal the Bay Comment Letter



December 3, 2018

Via electronic mail to ashleyp@sccwrp.org , steveb@sccwrp.org , and shana.rapoport@waterboards.ca.gov

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RE: Draft Work Plan for Marina del Rey Harbor Site-Specific Objective Study for Toxic
 (Dissolved Copper): Joint Comments of Los Angeles Waterkeeper and Heal the Bay

Dear Dr. Parks, Mr. Bay, and Ms. Rapoport:

Thank you for the opportunity to review and comment on the Draft Work Plan for the Marina del Rey Harbor Site-Specific Objective Study for Toxic (Dissolved Copper) (hereafter “MDR Draft Work Plan”). Los Angeles Waterkeeper (LAW) and Heal the Bay (HTB) jointly submit the following comments on the MDR Draft Work Plan.

I. Our organizations advocate on behalf of water quality in Marina del Rey Harbor and throughout Southern California.

LAW is a nonprofit environmental organization with over 25 years of experience and 3,000 members dedicated to protecting and restoring the inland and coastal surface and ground waters throughout Los Angeles County. LAW docks its boat (coated with Hullspeed copper free anti-fouling paint) in MDR Harbor, and has been a visible and active part of the MDR Harbor community for more than 20 years. Heal the Bay is a nonprofit environmental organization with over 30 years of experience and 15,000 members dedicated to making the coastal waters and watersheds of greater Los Angeles safe, healthy, and clean.

Together, our organizations have used a mix of advocacy, education, outreach, engagement, and (where necessary) litigation to ensure that Water Quality Objectives (WQO) and Total Maximum Daily Loads (TMDL) are promulgated as required; and that WQOs and

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TMDLs are properly protective of the environment and of all beneficial uses at all times. We also prioritize the compliance of all local water bodies with all applicable WQO and TMDL limits.

II. LAW and HTB have actively participated in the review of previously proposed SSOs and have generally been critical of SSOs as a weakening of existing environmental protections.

LAW and HTB have historically been quite skeptical of the use of Site Specific Objectives (SSOs) and/or site specific modifications to TMDLs when the effect is to raise regulatory numeric standards.¹ We have been particularly concerned with the use of Water Effect Ratios (WER) in setting SSOs, even more so than the use of Recalculation Procedures or other methods of deriving SSOs. Nonetheless, we recognize that SSOs (including WERs) are allowed (although not mandated) by regulation. (See for example 40 C.F.R. §131.11 subd. (b).) LAW and HTB have consistently stressed the absolute necessity that *any SSOs and site specific TMDL adjustments be as protective as the standards or limits they replace or modify*. Additionally, any promulgated SSOs and site specific TMDL adjustments must avoid potential degradation of water quality, and demonstrate consistency with all other applicable Anti-degradation Policies. (See State Water Resources Control Board Resolution 68-16; 40 C.F.R. § 131.12 subd. (a)(1), (a)(2)(ii).)

Despite our continued misgivings on the use of SSOs, our organizations see grounds for cautious optimism at this point in the process for SSO development in MDR Harbor. The role of SCCWRP has been beneficial, providing a layer of oversight and editorial independence that, from our perspective anyway, might not have always been present in the often-contentious Los Angeles River Copper and Lead SSO review process. We are also encouraged by the willingness of Regional Board staff to engage environmental groups such as LAW and HTB, and to address crucial issues transparently and early in the review process. While we anticipate occasional strong differences of professional opinion as the MDR Harbor SSO review process plays out, we will strive to make sure other participants in the process clearly understand the basis for our opinions. In other words, we recognize that engagement with study authors and regulators is a two way street.

We have reviewed the MDR Draft Work Plan, the interim and streamlined² WER guidance from the federal Environmental Protection Agency (EPA), and a previous WER study in San Francisco Bay that lead to the promulgation of Water Effect Ratios. We have also briefly reviewed several other WER studies in California that did not result in promulgation of Water Effect Ratios. We have divided the remainder of our comments into general comments, specific comments on the MDR Draft Work Plan, and comments on the interim EPA guidance.

¹ We are not aware of any SSO that had the effect of lowering regulatory numeric standards.

² We agree with the study authors (MDR Draft Work Plan, Page 3, fn 1) that the interim EPA guidance applies to the MDR Work Plan, but that the streamlined EPA guidance does not. We therefore offer general comments on only the interim EPA guidance, to the extent of any divergence between the two.

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III. General Comments:**A. The Regional Board should ensure that the approval of the MDR Draft Work Plan does not foreclose analysis of reasonable alternatives to a Copper WER.**

It is important to remember that the Regional Board must review any proposed final WERs (fWERs) pursuant to the California Environmental Quality Act (CEQA) as a proposed Basin Plan Amendment (BPA).³ Because significant resources are being invested now in studies that will presumably produce proposed fWERs, LAW and HTB wish to sound a note of caution that a range of reasonable alternatives to proposed WERs will need to be evaluated as part of the Basin Plan Amendment process. We wish to go on record now with our position that the BPA CEQA documents should evaluate the no-build alternative (i.e., keeping all current standards in place); as well as a range of alternatives to a copper WER including but not necessarily limited to a ban on copper anti-fouling paint in MDR Harbor implemented by California state agencies⁴; a partial ban designed to lower copper levels by the amount necessary to meet TMDL requirements; other source control measures implemented by the state and/or County of Los Angeles (such as an incentive program to convert to copper free paints); use of Resident Species Procedures and/or Recalculation Procedures instead of WER-based SSOs; and other reasonable alternatives that may emerge as the MDR Harbor SSO study process continues.

We also urge the Regional Board to ensure that planned compliance with anti-degradation policies (and to the extent applicable, anti-backsliding requirements) is integrated into the review process for any MDR Harbor SSO as early as possible. More broadly, we urge the Regional Board to integrate its reviews under the Porter-Cologne Water Quality Act of any SSOs with its CEQA review of the same. This approach is arguably required of the Regional Board anyway (see *Banning Ranch Conservancy v. City of Newport Beach* (2017) 2 Cal. 5th 919), but we believe that the anti-degradation analysis in particular would benefit greatly from a more integrated and holistic review approach. Required findings and any eventual Regional Board approval resolution would have more of a substantial evidentiary basis as well if the environmental reviews are better integrated. Our broad concern with integrated environmental review also extends to SCCWRP and the TAC review processes to some extent, even if *Banning Ranch*, strictly speaking, does not bind SCCWRP or the TAC. For example, integrating concerns with the anti-degradation analysis required as part of any eventual BPA into the MDR Harbor SSO study design now would tend to result in heightened attention to the critical condition. We believe such focus could only improve the final results of the MDR Harbor SSO study.

³ The BPA would also require approval by the California State Water Resources Control Board, the California Office of Administrative Law, and the federal Environmental Protection Agency.

⁴ LAW has already shared a memorandum with the Regional Board outlining its position that the County of Los Angeles is likely preempted by California law from directly regulating copper paint as a nuisance in MDR Harbor, but that the Water Boards are not so preempted, if a demonstration is made that the proposed Water Boards' regulatory action supports attainment of water quality objectives and/or TMDL waste load and load allocations.

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B. Previous WER studies should be considered illustrative, but should not be treated as creating binding precedent for the MDR Harbor SSO study.

Other SSO and WER studies can be illuminating, but should not be considered to create binding precedent on the methodology of the MDR Harbor SSO study. This is especially true given the overall lack of specific methodological guidance in the interim EPA guidance. This overall lack of guidance has led to considerable variation in WER study designs around California.

For example, the San Francisco Bay 2007 Proposed BPA and Staff Report for copper SSOs in San Francisco Bay was based on a copper WER study. However, that SSO process included only a perfunctory discussion of potential source control measures, devoting just one page of discussion in the Staff Report to control of copper anti-fouling paint. The Regional Board in San Francisco further declined to commit to any specific source control measures as part of the approval process. (See San Francisco Bay 2007 Proposed BPA and Staff Report, Page 5-6). We strongly urge the MDR Harbor SSO study authors as well as the Regional Board to make source control, particularly control of copper anti-fouling paint, a much higher priority for the MDR Harbor SSO study. We see source control as both a potentially viable alternative to a copper SSO, but also as a threshold inquiry to help determine whether a copper SSO is appropriate in MDR Harbor in the first place. It is thus conceptually difficult to separate source control from the MDR Harbor SSO study itself.

The San Francisco Bay 2007 Proposed BPA and Staff Report contained a fairly detailed anti-degradation analysis (an analysis we generally find much more informative than the conclusory analysis prepared in conjunction with the Los Angeles River SSOs). But one of the apparent conclusions in the anti-degradation analysis was that Numeric Effluent Limitations would likely not change in any existing permits if the proposed fWERs were approved, because of the effect of preexisting regulatory and permitting requirements (including anti-backsliding requirements). Since SSOs are widely perceived by both proponents and opponents alike as a form of regulatory relief, to us this conclusion begs the question of why any discharger with an existing permit would bother with a lengthy and expensive SSO study in the first place. (See 2007 Proposed BPA and Staff Report, p. 6-7.) A clear explanation (at a minimum) of the reasonably foreseeable regulatory effects (or lack thereof) of any MDR Harbor SSOs should be included with the MDR Harbor SSO study itself, given the importance of the anti-degradation policies to the ultimate success of the MDR Harbor SSO study.

The San Francisco Bay 2007 Proposed BPA and Staff Report relied on dissolved organic carbon (DOC) as a surrogate for toxicity in follow-up monitoring. This might be a defensible or even preferred approach for MDR Harbor, but study authors need to carefully justify any proposed use of that approach in MDR Harbor, rather than relying on the approved methodology of past studies.

Similarly, the San Francisco Bay 2007 Proposed BPA and Staff Report, as well as the WER study itself, relied on translators, since conversions from total to dissolved copper were necessary in San Francisco. It is unclear to what extent, if any, such translators would be needed

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or even appropriate in the MDR Harbor SSO study. The excessive copper discharges in MDR Harbor are almost wholly attributable to copper paint on boats instead of municipal effluent. The water quality objectives and TMDL limits most at issue in MDR Harbor already are tied to concentrations of dissolved copper instead of total copper. We do not see any evidence that discharges by regulated municipal treatment plants have a significant direct effect on bioavailability or toxicity of copper in MDR Harbor, so those effluent limitations expressed in terms of total copper concentration in Hyperion's discharge permits are apparently not an issue.⁵ Moreover, other site specific factors such as depth of the water column in MDR Harbor argue against the appropriateness of using translators.

Nonetheless, we request additional clarification on whether translators will be used in the MDR Harbor SSO study. We make this request because use of translators could reduce or even eliminate the margin of safety in the SSOs compared to the underlying standards, and thus effect the protectiveness of the SSOs and the potential for degradation of water quality and the related question of compliance with anti-degradation policies.⁶ For example, the 2007 SSO study in San Francisco Bay applied a geometrical mean-calculated translator of 0.70 to the Central and Lower Bay, and a geometrical mean-calculated translator of 0.37 to Suisun and San Pablo Bays. However, the observed highest- and most conservative observed- translator was 1.0 in the Central and Lower Bays,⁷ and 0.94 in Suisun and San Pablo Bays. The use of translators, in and of itself, therefore had the effect of significantly relaxing standards. (See 2007 Proposed BPA and Staff Report, Page 4-16.) For LAW and HTB, this feature of translators raises many of the same concerns that use of geometrical mean-based fWERs raised in the Los Angeles River.

The issues raised above are meant to be examples of questions that can arise when trying to apply the methodology of one SSO study to subsequent studies. It is not intended as an exhaustive list of concerns with using old SSO studies such as the 2007 San Francisco Bay study

⁵ Since this issue is not clearly explained in the MDR Draft Work Plan, we request clarification on whether discharges from Hyperion might have a significant direct effect on toxicity of copper in MDR Harbor.

⁶ The most conservative copper translator is 1.0, which implies that all copper present in the water column is in dissolved form. The California Toxics Rule contains an approved default translator of 0.83, whose use in SSO studies we would find problematic because 1) there is nothing site-specific about a default translator, so the appropriateness of including this default term in a study meant to support *site specific objectives* is questionable; and 2) translators are typically derived using geometrical means of field samples, so by definition use of the calculated geometrical mean translator provides a less conservative standard than reliance on the highest observed translator would provide. Whether the use of a mean translator also equates to a less protective standard depends on the margin of safety in the original standard, but it seems likely that use of a very low translator would raise many of the same issues as use of a very high WER. Since the two terms could be combined in any SSOs, we have a number of unresolved questions regarding translators. Use of translators is seemingly analogous to promulgating a WER-within-a-WER. Translators were not an issue in the Los Angeles River SSOs, so possible use of translators present an issue of first impression for us here.

⁷ The measured 1.0 translator strongly suggests that use of any other translator was inappropriate.

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as definitive guides to the current SSO study in MDR Harbor. We also recognize that some methodological issues (perhaps such as translators) might prove irrelevant for the MDR Harbor SSO study.

The broader point we are trying to illuminate with this discussion of the 2007 San Francisco Bay copper SSO is the lack of specific recommended practices in the interim EPA guidance on the proper design of SSO studies. The lack of guidance in the interim EPA guidance creates difficulty in making apples-to apples comparisons of methodology across SSO studies. Unfortunately, reinventing the wheel may be a cost of this lack of specific guidance. LAW and HTB therefore request that if specific methodologies, findings, etc. from previous SSO studies are being imported into the MDR Harbor SSO study, that the study authors include an explanation of the appropriateness in the current context of MDR Harbor, and how the methodology proposed could affect the margin of safety and the protectiveness of the site specific objectives and/or site specific TMDL modifications in MDR Harbor. Our hope is to avoid or resolve any methodological issues early on in the study process, to make the MDR Harbor SSO study as robust and transparent as possible.

IV. Comments on the MDR Draft Work Plan:

To facilitate consideration of our comments on the MDR Draft Work Plan by SCCWRP and the TAC, our comments are presented essentially in the order in which the topics appear in the MDR Draft Work Plan itself. The order of discussion is therefore not necessarily reflective of our organizations' biggest concerns. We have highlighted major concerns as needed for clarity.

Page 2: We suggest revising the text of the first full paragraph to reflect that site specific parameters can increase, as well as decrease, toxicity to aquatic organisms (as would be reflected whenever $WER < 1.0$). In addition, we request a comparison of the margin of safety in the unadjusted WQOs, versus the margin of safety in any WER-adjusted standards. The use of *M. galloprovincialis* as a toxicity test species (see MDR Draft Work Plan, p.10), appears to increase the margin of safety of associated with any WER-adjusted SSOs, but it is unclear whether the overall effect of the SSO would be to lessen the margin of safety compared to the underlying standards.

Page 2: The Biotic Ligand Model (BLM) is not approved for use in marine waters, but the MDR Draft Work Plan relies heavily on the use of the BLM. This raises a potentially major concern, although we are open to persuasion on use of the BLM in marine waters. We request clarification on why the authors believe use of the BLM is appropriate despite the lack of approval for use of the model in marine waters. Also, we recommend considering revision of the MDR Draft Work Plan to include an alternative study design, if reliance on the BLM turns out to be inappropriate or scientifically less than robust (or if use of the BLM remains unapproved for marine waters as sample WERs are derived).

Page 3: LAW and HTB are also concerned that use of the BLM to target the conditions likely to result in the lowest WER (i.e., the critical condition), may not be appropriate if the

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BLM is not approved for use in marine waters. In any event, *it is of the utmost importance that the MDR Harbor SSO study demonstrate that the critical condition has been fully evaluated* as part of the study, regardless of whether the BLM is used or not.

Page 3: (see also Page 8): Similarly, use of the BLM to generate “comparative” WERs is also of concern for the same reasons. The dispute over the critical condition was one of the single most contentious items in the Los Angeles River Copper WER Study in 2015, so we urge the study authors to carefully justify any claims about the timing of the critical condition, especially if the MDR Harbor SSO study relies of the critical condition relies on a model not approved for use in marine waters.

Page 4: Assuming successful resolution of the methodological concerns expressed elsewhere, we agree that the fWERs can be used to adjust both the CCC (chronic) and CMC (acute) WQOs, as well as TMDL adjustments associated with the same location.

Pages 5-6 and Page 8: The summary of various other marine WER/SSO studies raises the question of to what extent the MDR Draft Work Plan relies on methodologies in prior studies. The authors intend to “us[e] methods shown to be effective in recent successful California WER studies.” (MDR Draft Work Plan, Page 8.) “Success” is not defined, however, and only one of the summarized studies resulted in promulgated WERs (which to us seems like a necessary if insufficient condition for a determination of “success”).

LAW’s Senior Attorney spoke to his counterpart at San Diego Coastkeeper about the SSO studies there, and he recalled that the San Diego Regional Board had serious concerns with the design of the Shelter Island Yacht Club WER study (ironically, the WER study that produced the lowest WER values of any of the studies summarized). The MDR Harbor SSO study authors may thus wish to consult with San Diego Regional Board staff for additional information on these apparent concerns. (San Diego Coastkeeper unfortunately could not locate its comment letter on this study in its files, so we are passing on all the additional information we have regarding this review.)

Page 10: The authors discuss the significant sources of potential variability in calculation of WERs. With a multi-year dispute over the critical condition in the Los Angeles River fresh in our minds, along with a keen desire to avoid such a dispute this time around, we urge the authors, Regional Board staff, SCCWRP staff, and the Technical Advisory Committee members to consider basing fWERs on the lowest value produced by methodologically correct testing, rather than relying on a geometric mean (or any type of averaging) of several values. This is especially important if the sample WERs (sWERs) show high variability.

Again, the Los Angeles River Copper WER study provides a relevant negative example for us. There, the geometrical mean of five sWERs (6.196, 8.161, 8.689, 9.215, and 17.15) for the Rio Hondo tributary was calculated, yielding an fWER of 9.69. Because of the high variability, and the inclusion of the outlying sWER of 17.15 in the fWER calculation, the fWER was considerably higher than the critical condition, which by definition had to occur with a WER

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of no higher than 6.196.⁸ In fact, the fWER was higher than 80% of the sWERs. This suggests that the WER- adjusted SSO for Rio Hondo could be considerably less protective than the underlying standard it replaced, and could often allow for increased toxicity. Other tributaries and the LA River mainstem had the same methodological issue. In addition, we believe a strong case exists that WER-based SSO should generally use the lowest sWER value obtained plus a margin of safety, rather than an average of values.

Page 14: We believe the interim EPA guidance is generally poorly suited to Southern California's flashy and highly variable hydrologic cycle, with one of the major shortcomings being that the guidance allows fWERs to be promulgated on as few as three field samples. We strongly suggest that the study design for the MDR Harbor SSO study include more than three sampling events, and that the number of sampling events in the study (as well as exclusion of data from any sampling event from fWER calculations) be fully justified.

Pages 16-17: We request citations to support the statement that DOC concentration is the primary variable controlling bioavailability of copper in marine systems. Additionally, we request additional evidentiary support that DOC concentration is closely correlated with BLM modeling results, and an explanation whether this DOC/BLM correlation is being used to justify reliance on BLM results despite lack of EPA approval for use of the BLM in marine waters. Again, we are open to persuasion on this issue, but we believe additional evidence in support of the study author's position is warranted.

Page 17: Available DOC data suggests that the lowest DOC levels tend to occur in the front basins and main channel of MDR Harbor, with back basins trending towards higher concentrations. While this distribution of concentrations makes intuitive sense, given how crucial distribution of DOC appears to be for the defensibility of the study results (including the calculation of fWERs), we recommend that additional DOC monitoring be undertaken prior to WER sampling to confirm the DOC concentration distribution pattern in the study area.

Page 18: Similarly, we recommend additional confirmation backed by rigorous data and robust modeling that the critical condition is likely to occur during dry weather in winter or spring.⁹ Since this period is quite different from the apparent occurrence of the critical condition in the freshwater system of the Los Angeles River (where the Regional Board found the critical condition to occur during the peak of the dry season), we request additional discussion of why this large temporal difference in occurrence of the critical condition might result between the freshwater Los Angeles River and the marine waters of MDR Harbor.

⁸ It seems likely that the true critical condition at Rio Hondo would be even lower, since only 5 sample WERs were calculated and the sWERs exhibited high variability.

⁹ Ironically, during the review of the Copper WER study for the Los Angeles River and its tributaries, our organizations suggested that dry periods within the rainy season were very plausible candidates for the occurrence of the critical condition, a position that was hotly disputed by both the study authors and the Regional Board at the time. We suggest, at a minimum, that study authors consider a more precise definition for wet and dry weather conditions than that provided in the interim EPA guidance.

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Page 18: Given the probable lowest DOC concentrations in the main channel, we recommend considering adding a second water sampling station in the main channel, in the area of the channel to the east of the terminus of Bora Bora Way, to improve the robustness of the study results.

Page 20: We have concerns that a single sampling event to confirm that wet weather copper bioavailability is lower than other periods is insufficient, especially since the study authors believe that winter or spring contains the critical condition. We recommend that the study authors consider adding at least a second sampling event in wet conditions.

Page 20: We support the collection of grab samples, and support analyzing zinc concentrations in those samples. However, we ask for greater clarification of the claim that inclusion of zinc in the study will facilitate understanding copper toxicity.

In other words, we request a greater discussion of how the study design will account for possible synergistic effects of multiple toxins (zinc and lead come to mind in particular). It is unclear how the study design can account for synergistic effects when the test methodology isolates copper for addition to test vessels, but the extent of any variation in copper discharges is unclear,¹⁰ and zinc/lead loading probably tend to occur in unison in real world conditions (along with loading of other pollutants, some of which might exacerbate the toxicity of the metals, and some of which might mitigate the toxicity). This issue proved contentious in the Los Angeles River proceedings, and being familiar with the LA River WER study, we have the impression that environmental advocates and regulators spent much time talking past each other on the issue of synergistic effects, so we would like as much clarification as possible early in the process.

One possible solution would be to essentially sidestep the issue, by demonstrating that the MDR Draft Work Plan builds in a very significant margin of safety, so that artifacts of test methodology do not lead to an underestimate of copper bioavailability. We reiterate how important it is to the success of the study to obtain an accurate estimate of copper bioavailability. If bioavailability is underestimated, proposed fWERs are likely unrealistically high, with all of the attendant problems for protectiveness of the standards, possible degradation of water quality, etc., that such a situation would entail.

The other overlapping possibility is to identify the lowest possible WER and set the SSOs accordingly.¹¹ In other words, use the critical condition, and not a geometric mean, as the basis for the SSOs. One of the few areas where, in our view, the interim EPA guidance actually provides useful methodological recommendations concerns the potential for synergistic effects, and the interim EPA guidance suggests that it may be most cost-effective to base SSOs on the

¹⁰ We request a fuller discussion of whether copper discharges are in fact approximately constant, or whether they tend to increase during events when discharges of other pollution tends to increase.

¹¹ Logically, we would see this as the lowest sWER, plus some defensible margin of safety, or even a non-arbitrary “fudge factor” that can garner consensus support.

LAW/HTB MDR Draft Work Plan Comments

lowest WER. (See interim EPA guidance at p. 135.) In any event, we urge study authors to more fully explain how the MDR Draft Work Plan accounts for synergism, additivity, or reduced efficacy of detoxifying metal-organic complexes when multiple metals are present.

Page 27: *The question of whether the WER sample size and precision allows for a defensible fWER is extremely important.* We again urge the study authors to use the lowest WER obtained plus a margin of safety, rather than an average of sWERS, to ensure that the critical condition has been captured, and that the SSOs do not suffer from a potentially serious anti-degradation policy consistency problem as a result.

Page 28: In a similar vein, *LAW and HTB believe that if insufficient data exists to support “the desired level of precision and seasonal specificity” of fWERS after completion of the study, then Regional Board approval of a Basin Plan Amendment based on those fWERS almost by definition would violate both CEQA and Porter-Cologne, as any findings would lack substantial evidentiary support and/or would not proceed in manner required by law.* (See California Code of Civil Procedure §1085 and §1094.5.) We thus strongly encourage revision to this section of the MDR Draft Work Plan, to include a firm commitment to either collect such data until the data set is robust enough to support calculated fWERS, or else to discontinue the process of seeking approval of SSOs if data is insufficient to support calculation of defensible fWERS.

Page 31: We support having public comment periods at key points during the MDR Harbor SSO study process. We strongly recommend formal written responses to comments be prepared, even if the Regional Board believes it does not have a strict legal obligation to prepare such a document as part of its Work Plan review. We recognize that preparing written responses at multiple points in the MDR Harbor SSO study process will be very time consuming and can seem a thankless task. We can assure you that the same is often true of writing multiple comments in the first place. However, the process of preparing formal written responses ensures that 1) all public comments are examined and considered; 2) the author of the comments knows how the comments have been considered and has a sense of the disposition of the issue raised; and 3) issues that might otherwise linger and fester are potentially resolved.¹² It also offers all parties the benefit of a written record, and demonstrates that the Regional Board takes engagement with various interests and perspectives seriously at every step of the process.

We also request that data collected to support the MDR Harbor SSO study be made available in as close to real time as possible, to further enhance transparency, and to provide for potential feedback to allow identification (and presumably correction) of any problems as early in the process as possible.

///
///

¹² As a practical matter, issues that fester would likely reappear as written comments during the BPA review, at which point written comment responses from the Regional Board would be required anyway. (See Pub. Res. Code §21080.5 subd. (2)(D).)

LAW/HTB MDR Draft Work Plan Comments

V. Concerns with the Interim EPA Guidance:

Many of the following comments on the “June 1994 Environmental Protection Agency Interim Guidance on the Determination and Use of Water Effect Ratios for Metals” (i.e. the interim EPA guidance) are reflected above as applied to specific issues associated with the MDR Draft Work Plan. Nonetheless, our organizations have sufficient concern with the interim EPA guidance generally that we wish to go on record here with those concerns.

First, we were greatly encouraged and relieved during the course of the initial TAC call when Mr. Bay of SCCWRP referred to the interim EPA guidance as an “aspirational” document not to dictate the exact conduct of the MDR Harbor SSO study. Bringing to mind Voltaire’s quip about the Holy Roman Empire, we do not consider the interim EPA guidance as “interim” in any meaningful sense of the word (it will celebrate its 25th birthday during the course of the MDR Harbor SSO study), nor do we believe it provides much in the way of useful guidance. However, we will assume, arguendo, that the guidance was actually produced by EPA, or at least under its direction.

One fundamental problem with the document is that it assumes the hydrologic cycle of Southern California is essentially the same as anywhere else. As even a casual observer would recognize, this is far from true. Our organizations have long advocated that the California State Water Resources Control Board promulgate California-specific WER guidance, but apart from production of a draft WER policy over a decade ago we have had no success on this front. So, from our perspective we are essentially stuck with very old WER guidance that does not speak to the extreme variability of California’s hydrologic cycle; allows potentially wholesale changes to WQOs and TMDL limits based on as little as three field samples; and provides only vague guidance as to the timing of when those samples should even occur. (See for example, Page 48 of the interim EPA guidance, which cautions that samples should not be “unduly affected by recent runoff events.”)

We are also concerned that the document allows extrapolation of assumptions about toxicity over a wide range of organisms. This is less of a concern in this particular instance, since the study design is using the most sensitive species in the national data set for marine organisms, and is using the same organism upon which California Toxics Rule copper criteria are based. (MDR Draft Work Plan, Pages 10-11.) Nonetheless, this breezy acceptance of extrapolation to very divergent organisms raises concerns generally.

The interim EPA guidance is silent on maintaining a margin of safety to account for possible errors in measurements. Because setting a WER too high could (and in many cases, likely would) result in increased toxicity and/or water quality degradation, this is a major omission.


Even where the interim EPA guidance uncharacteristically offers specific help to study authors- most notably by suggesting identification of the lowest possible WER and setting the SSOs accordingly to account for potential synergistic effects that are difficult to account for in study design- the guidance thereby creates an internal inconsistency with the definition of the

LAW/HTB MDR Draft Work Plan Comments

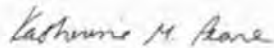
Sincerely,



Arthur Pugsley, M.S., LL.M.
Senior Attorney
Los Angeles Waterkeeper



Melissa von Mayrhauser, M.Sc.
Watershed Programs Manager
Los Angeles Waterkeeper



Katherine Pease, Ph.D.
Director of Science & Policy
Heal the Bay



Annelisa Moe, M.S.
Water Quality Scientist
Heal the Bay

cc (via electronic mail): Ms. Jenny Newman (Jenny.Newman@waterboards.ca.gov)
Mr. Michael Tripp (mtripp@bh.lacounty.gov)

Stakeholder (Johntommy Rosas) Comment Letter

Ashley Parks

From: Johntommy Rosas <tattnlaw@gmail.com>
Sent: Wednesday, October 31, 2018 1:00 PM
To: Ashley Parks; Hanks, Michael@Waterboards; Rapoport, Shana@Waterboards; JOHNTOMMY ROSAS
Subject: RE:DRAFT WORK PLAN MARINA DEL REY HARBOR SITE-SPECIFIC OBJECTIVE STUDY
Attachments: Citations for OSHA, etc - Rosas - MIACC-AFS mtg 10-16-18 (1).docx

Hi Dr. Ashley Parks/Shana/Michael,
 I made this video presentation for the Fall 2018 Marina Interagency Coordinating Committee and Anti-fouling Strategies Workgroup-
 I hope you folks can implement this information for your study-
 thanks ,jt
<https://www.youtube.com/watch?v=mvTqmKY8pSY>

1. <https://www.nace.org/Corrosion-Central/Corrosion-101/Galvanic-Corrosion/>
2. <http://www.cruisersforum.com/forums/attachment.php?attachmentid=172105&d=1529467584>
3. <https://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/eh0805.pdf>
4. <https://newcontent.westmarine.com/wm-img/westadvisor/articles/Shore-Power-13.jpg>
5. http://assets.blueseas.com/files/resources/newsletter/images/Ground_Fault.png
6. http://www.forestriverforums.com/attachments/photobucket/img_1146680_0_ebf4cd5eca16c8ae1d3bef0d73c8bef4.gif
7. <https://darchive.mblwhoilibrary.org/bitstream/handle/1912/191/chapter%2022.pdf?sequence=31>
8. <https://www.ecmweb.com/content/case-hot-marina>
9. <https://www.electricschockdrowning.org/esd--faq.html>
10. <http://www.boatus.com/seaworthy/assets/pdf/electric-shock-drowning-explained.pdf>
11. <http://www.boatus.com/seaworthy/assets/pdf/marina-dock-safety.pdf>
12. <https://law.resource.org/pub/us/cfr/ibr/001/abyc.E-09.1990.pdf>
13. <http://www.uscgboating.org/regulations/assets/builders-handbook/ELECTRICAL.pdf>
14. https://www.waterboards.ca.gov/about_us/performance_report_1617/plan_assess/docs/fy1314/11112_r4_marinadelrey_toxics.pdf
15. https://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/96_New/Final%20MdR%20Sediment%20Characterization%20Report_processed.pdf
16. https://www.cdpr.ca.gov/docs/dept/prec/2017/012017_af_paints.pdf
17. <https://www.paint.org/article/marine-coatings-making-sense-u-s-state-local-mandates-copper-based-antifouling-regulations/>
18. https://www.epa.gov/sites/production/files/2015-10/documents/2001_10_30_nps_mmssp_section4.pdf
19. <https://www.dtsc.ca.gov/PollutionPrevention/upload/Scappingand-SandingHullFinal.pdf>
20. https://www.usace.army.mil/Portals/2/docs/civilworks/recreation/Water_Safety/tools/guidelines_safe_operation_maint_marinas.pdf?ver=2016-07-25-130937-857
21. <https://www.osha.gov/Publications/osha2268.pdf>
22. <https://www.osha.gov/laws-regs/regulations/standardnumber/1915/1915SubpartC>
23. https://www.osha.gov/OshDoc/data_MaritimeFacts/shipbreaking-factsheet.pdf
24. https://www.osha.gov/dts/maritime/standards/guidance/shipyard_guidance.html
25. https://www.osha.gov/dts/maritime/sitc/ships/surfaceprep/surfaceprep_all-in-one.pdf

26. <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.16>
27. https://www.osha.gov/pls/imis/sic_manual.display?id=921&tab=description
28. <https://www.dtsc.ca.gov/PollutionPrevention/upload/MediaBlastingFinal.pdf>
29. https://www.cdpr.ca.gov/docs/dept/prec/2017/012017_af_paints.pdf
30. <http://www.dfo-mpo.gc.ca/Library/52635.pdf>
31. ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2003_04AnnualReport/ar04-schiff_pg41-49.pdf
32. <https://escholarship.org/content/qt4dr8m4h1/qt4dr8m4h1.pdf>
33. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3919178/>
34. <http://www.dtic.mil/dtic/tr/fulltext/u2/a284381.pdf>
35. https://www.researchgate.net/publication/269466237_Copper_emission_loading_from_antifouling_paints_and_their_relation_to_industrials_and_waste_water_effluents_to_the_Suez_bay_transit_area
36. https://www.equipcoservices.com/sales/ysi/pro30.html?clid=EAIaIQobChMIzvfraqeFP3QIVyQoqCh3f3QUKEAAYASAAEqJoA_D_BwE
37. <https://www.ysi.com/File%20Library/Documents/Manuals%20for%20Discontinued%20Products/038503-YSI-Model-85-Operations-Manual-RevE.pdf>
38. <http://www.electrochemsci.org/papers/vol12/120201232.pdf>
39. <https://www.paint.org/article/use-copper-based-antifouling-paint-u-s-regulatory-update/>
40. https://www.wartsila.com/docs/default-source/marine-documents/encyclopedia/wartsila-o-marine-encyclopedia.pdf?utm_source=web&utm_medium=web&utm_term=marine&utm_content=encyclopedia&utm_campaign=encyclopedia
41. [http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-the-Control-of-Harmful-Anti-fouling-Systems-on-Ships-\(AFS\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-the-Control-of-Harmful-Anti-fouling-Systems-on-Ships-(AFS).aspx)
42. <http://www.imo.org/en/OurWork/Environment/Anti-foulingSystems/Pages/Default.aspx>
43. https://www.google.com/search?q=boat+hull+cleaning+divers&num=20&newwindow=1&rlz=1C1CHBD_enUS807US807&source=lnms&tbn=isch&sa=X&ved=0ahUKewjj_7u968_dAhULKXwKHfqsB4EQ_AUIDygC&biw=1816&bih=974&dpr=2
44. <http://events.nace.org/conferences/IMCS2008/papers/15.pdf>

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JOHN TOMMY ROSAS
 TRIBAL ADMINISTRATOR
 TRIBAL LITIGATOR -TATTN JUDICIAL # 0001
 TONGVA ANCESTRAL TERRITORIAL TRIBAL NATION
 A TRIBAL SOVEREIGN NATION UNDER THE UNDRIP AND AS A TREATY [s] SIGNATORIES RECOGNIZED TRIBE, INCLUDING BY THE STATE OF CALIFORNIA WITH HISTORICAL & DNA AUTHENTICATION ON CHANNEL ISLANDS AND COASTAL VILLAGES - AND AS A CALIFORNIA NATIVE AMERICAN TRIBE / SB18-AB 52-AJR 42-ACHP/NHPA - CALIFORNIA INDIANS JURISDICTIONAL ACT U S CONGRESS APPROVED MAY 18, 1928 45 STAT. L 602

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Ashley Parks

From: Johntommy Rosas <tattnlaw@gmail.com>
Sent: Wednesday, October 31, 2018 3:45 PM
To: Ashley Parks; Hanks, Michael@Waterboards; Rapoport, Shana@Waterboards; JOHNTOMMY ROSAS
Subject: Re: DRAFT WORK PLAN MARINA DEL REY HARBOR SITE-SPECIFIC OBJECTIVE STUDY

I hope to see sufficient testing and additional testing areas per this citation -
 " [The USEPA \(1994\) Interim Guidance recommends that WER analyses be conducted over a range of conditions so that the results are representative of the variations in water quality at the site.](#)

[The guidance also states that the study should include multiple stations distributed over a minimum of three separate sampling events that include different seasons and locations. "](#)

Its also important to test appx 2 years to get a secondary year to compare with -
 in the various seasonal events and effects that occur from the seawater
 and the actual vessels different discharges from stray electrical currents
 -and those affects that cause additional antifouling paint /copper other noble metals in the
 coatings to discharge from all vessels -
 the suggested testing areas are not sufficient -there should be an additional 22 stations and
 22 locations used for metals analysis

["The station locations for the study are a subset of 11 candidate stations used in previous monitoring surveys \(Figure 3\). These stations include nine locations used for metals analysis in the Mdr Harbor TMDL Coordinated Integrated Monitoring Program "](#)

the some testing areas should be near the vessels as well- where the actual discharging occurs-
 there should be habitat testing additionally to have the negative impacts on sea life / habitat
 etc- documented-
 thanks jt

On Wed, Oct 31, 2018 at 12:59 PM Johntommy Rosas <tattnlaw@gmail.com> wrote:

Hi Dr. Ashley Parks/Shana/Michael,
 I made this video presentation for the Fall 2018 Marina Interagency Coordinating Committee
 and Anti-fouling Strategies Workgroup-
 I hope you folks can implement this information for your study-
 thanks ,jt
<https://www.youtube.com/watch?v=mvTgmKY8pSY>

1. <https://www.nace.org/Corrosion-Central/Corrosion-101/Galvanic-Corrosion/>
2. <http://www.cruisersforum.com/forums/attachment.php?attachmentid=172105&d=1529467584>
3. <https://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/eh0805.pdf>
4. <https://newcontent.westmarine.com/wm-img/westadvisor/articles/Shore-Power-13.jpg>
5. http://assets.blueseas.com/files/resources/newsletter/images/Ground_Fault.png
6. http://www.forestriverforums.com/attachments/photobucket/img_1146680_0_ebf4cd5eca16c8ae1d3bef0d73c8bef4.qif
7. <https://darchive.mblwhoilibrary.org/bitstream/handle/1912/191/chapter%2022.pdf?sequence=31>
8. <https://www.ecmweb.com/content/case-hot-marina>
9. <https://www.electricshockdrowning.org/esd--faq.html>
10. <http://www.boatus.com/seaworthy/assets/pdf/electric-shock-drowning-explained.pdf>

Ashley Parks

From: Johntommy Rosas <tattnlaw@gmail.com>
Sent: Wednesday, October 31, 2018 4:04 PM
To: Ashley Parks; Hanks, Michael@Waterboards; Rapoport, Shana@Waterboards; JOHNTOMMY ROSAS
Subject: Re: DRAFT WORK PLAN MARINA DEL REY HARBOR SITE-SPECIFIC OBJECTIVE STUDY

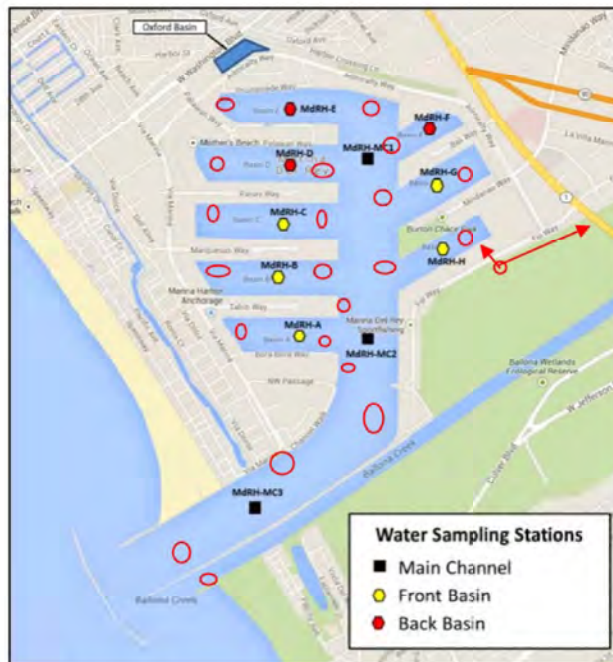


Figure 3. Candidate sampling stations in Marina del Rey Harbor.

please my suggested test stations - please include the fiji channel/ditch [has the areas with arrows] and ballona[bayona] creek channel that goes into the state BWER -as well thanks jt

On Wed, Oct 31, 2018 at 3:44 PM Johntommy Rosas <tattnlaw@gmail.com> wrote:

I hope to see sufficient testing and additional testing areas per this citation -
 " [The USEPA \(1994\) Interim Guidance recommends that WER analyses be conducted over a range of conditions so that the results are representative of the variations in water quality at the site.](#)
[The guidance also states that the study should include multiple stations distributed over a minimum of three separate sampling events that include different seasons and locations.](#) "
 Its also important to test appx 2 years to get a secondary year to compare with - in the various seasonal events and effects that occur from the seawater and the actual vessels different discharges from stray electrical currents

Ashley Parks

From: Johntommy Rosas <tattnlaw@gmail.com>
Sent: Tuesday, December 11, 2018 4:40 PM
To: Ashley Parks; JOHNTOMMY ROSAS; Michael Tripp; Kang, Jim@Waterboards; Rapoport, Shana@Waterboards
Subject: RE DRAFT WORK PLAN MARINA DEL REY HARBOR SITE-SPECIFIC OBJECTIVE STUDY

I have reviewed your draft document and I approve of it -
 The TONGVA NATION continues to fully support of the clean up and remediations for the MDR HARBOR and the SANTA MONICA BAY as approved by the US EPA and CA STATE WATER BOARD-
 which is our territorial waters historically and now as recognized by UN UNDRIP which the USA has adopted -
 and the state of ca has as well under AJR 42-
 thank you
 /S/ JOHNTOMMY ROSAS

--

JOHN TOMMY ROSAS
 TRIBAL ADMINISTRATOR
 TRIBAL LITIGATOR -TATTN JUDICIAL # 0001
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Stakeholder (Douglas P. Fay) Comment Letter

December 3, 2018

To: USEPA, LARWQCB, LA County BOS, SCCWRP, TAC Members, and other Interested Parties

Re: Draft Work Plan Marina del Rey Site-Specific Objective Study review, comments and concerns by Douglas Fay

Thank you for the opportunity to comment on this controversial Work Plan. I represent the third generation of documented Fay family involvement with the Marina del Rey (MDR) Harbor and Santa Monica Bay (SMB). My children represent the fourth. In 1949, my fisherman grandfather Rimmon Loraine Fay was a member of the pioneering Ocean Fish Protective Association, which formed when our local fishery showed signs of collapsing, which it did. My ocean lifeguard and marine scientist father Dr. Rimmon C. Fay, with PhDs in Chemistry and Oceanography was considered by many as the leading SMB expert for decades. In 1962, the year I was born, my parents bought a home on Howard Street adjacent to the MDR Harbor, where I lived for 3 decades. I have been swimming and diving in the SMB my entire life. I am a certified professional scuba instructor with hundreds of dives in the SMB. I have attended several meetings and commented on MDR water quality concerns in the past.

I have read the Draft Working Plan and am alarmed that this is in fact not a working plan that protects aquatic life in the MDR Harbor as stated. The Introduction of the Draft Working Plan clearly outlines that this is a "reconsideration" of TMDLs for Toxins based on the rationale that there is a need to quantify and/or justify creating a legally and "scientifically defensible" water quality criterion to protect aquatic life in MDR Harbor. It is deception. Without creating a working plan that removes over 50 years of accumulated toxins and organic matter this is impossible. The intent of the Draft Working Plan is to reduce environmental protection by paying SCCWRP and others \$4 million to create studies that say everything is okay when in fact it is not. Funding and creation of this study is exempt from CEQA. This move is also an environmental injustice.

I have stated that, "For the recreational users, boaters, divers, tourists, residents and marine life that live and play in Marina del Rey, the Harbor is our aquarium of the Pacific. Aquariums must be maintained. The County of Los Angeles (County) is responsible for maintaining the Harbor. Unfortunately, since the Harbor was built, they have failed to maintain the water quality at an acceptable level.

The Working Plan solution to the 303(d) list impairment that I proposed years ago was for the County to purchase or custom build a commercial boat that can remove, in an environmentally friendly way, vacuum not dredge, an average of 1 ton of sediment per day, transfer the material to a commercial truck, and have it taken to a land based facility for recycling and reuse. Within 2 years, approximately 600 tons of sediment, generated primarily from in water hull cleaning, would be removed and water quality will significantly improve. Ongoing maintenance would be required. The man-made marina does not have adequate circulation. It is a design flaw that requires maintenance as mitigation.

Unfortunately, in 2014, rather than implement a working plan to remove the toxins and organic matter, the County BOS approved another study. There have been several over many years. This one at a cost of \$4 million.

The question that needs to be asked is: Do the decision makers and stakeholders clearly understand the objective and reconsideration of this proposed Draft Work Plan? I do not believe the stakeholders do. I know further delays that prevent implementing a solution impose a significant impact on aquatic life.

Absent from Background description is 1954 US Public Law, House Document No.389, the Federal document that outlines the creation and purpose of the Harbor. In 1994, the US House of Representatives approved a Resolution - Docket 2455 that states the Secretary of the Army is required to review a report by the Chief of Engineers on House Document No.389. A determination was to be made prior to environmental restoration projects. Unfortunately, there is no documentation that shows a determination has been made and controversial restoration projects have proceeded.

The November 15, 2018 publication of The Argonaut newspaper Page 10, A Piece of Marina History Goes up for Auction shows an early-1960s watercolor depicting the original design study for dredging Marina del Rey Harbor painted by an architecture coordinator for Los Angeles County. It shows a landscape consistent with what is described in House Document No. 389.

In 1998 the MDR Harbor was added to the 303(d) list by the LARWQCB for high copper levels.

In 2014 the toxin TMDLs were revised and adopted by the LARWQCB and SWRCB.

The SWRCB Resolution 2014-0049 lead to the SSO study in 2017.

In the Development of Site-Specific Objectives, it states protection of aquatic life is uncertain. It further states that this study does not account for physical constituents for example, particulate and dissolved organic matter.

The proposed study is not inclusive and will not produce a comprehensive solution that will protect aquatic life. It does not mention providing the required level of protection for human health. Commercial divers and recreational swimmers enter the Mdr Harbor waters daily.

WER is not applicable to Mdr.

The Toxicity Test Species and Method Selection is limited to one species, *M. galloprovincialis* embryos.

The Water-Effect Ratio Study Design – Station Locations excludes Oxford Basin. Why?

The Public Participation Plan states public participation will be actively sought. Absent from the Draft Work Plan is public comment and Q&A at the TAC review meetings and the first public workshop. Why? Limiting public participation to only being able to comment at the final second public workshop is insufficient.

Under section VII Implementation Report is California Water Code Section 13241 anti-degradation review (as appropriate). If the Draft Work Plan proceeds as proposed degradation of the Harbor will continue and reviewing now is appropriate.

Under section VIII Project Schedule is the Work Plan. April 19, 2015, the County BOS approved SCCWRP to initiate the SSO Study.

The Quality Assurance Project Plan will be conducted by SCCWRP. For me, given the history of failed scientific research integrity at SCCWRP, this is problematic. It is well documented in *Dirty Water* by Bill Sharpsteen that Willard Bascom altered SMB pollution data submitted to him by one of his scientists Dr.

David Brown when he ran SCCWRP. Eventually, the City of Los Angeles lost the 301(h) waiver battle in court at a cost of over \$3.5 billion dollars. The scientific evidence that forced them to upgrade sewer infrastructure throughout LA County and at Hyperion came from my marine scientist father Dr. Rimmon C. Fay. With Dr. Fay out of the picture, he passed away January 1, 2008, there are no credible independent scientists to ensure Bascom's behavior isn't continuing at SCCWRP and influencing this process in other ways.

When I read that Richard Ambrose was 1 of 3 TAC Members for this Draft Work Plan and study the alarm bells went off. Like Bascom, Ambrose is a person that is not trusted by SMB environmental activists. The controversial Malibu Lagoon restoration project he supported was not comprehensive in relation to the watershed and SMB. This past summer, after project completion, a massive fish die-off occurred in the Malibu Lagoon. The upstream barrier Rindge Dam that significantly impedes the endangered Southern Steelhead trout from historical migration territory, has not been removed. Upstream pollution and water quality concerns legalized through the TMDL process do not provide adequate protection for the endangered Southern Steelhead. Ambrose also supports the controversial Ballona Wetlands Ecological Reserve (BWER) Alternative 1 proposed alternative, that will transform what was historically a positively charged fresh water estuary into a full tidal habitat. Again, approved through the TMDL process, untreated urban runoff would be introduced into the fragile BWER under the assumption that wildlife areas can assimilate the synthetic toxins without harming species. I have never read a valid scientific report that states unlike in humans, synthetic toxins do not harm wildlife. Maintaining the adjacent Mdr Harbor that already is a full tidal habitat for aquatic species would negate the need to transform the BWER. Through his involvement with the Santa Monica Bay Restoration Commission (SMBRC), as a scientist Ambrose has done nothing to right the wrongs of this commission's actions. Currently this commission operates under the SWQCB and is funded in part by the USEPA's National Estuaries Program (NEP) which states the SMB is a 312 square mile estuary, which it is not. It is a bay. His scientific integrity appears to be compromised by politicians. Richard Ambrose does not belong on the TAC. He should be replaced.

The intent by US Representative Mel Levine and California Assemblyman Tom Hayden decades ago, with NEP funding, was to study SMB pollution for 5 years and draft a plan that included the creation of the Santa Monica Bay National Marine Sanctuary. If the sanctuary designation had happened, which it didn't, the Mdr Harbor would have been required to be maintained. There is sufficient revenue generated in unincorporated Mdr to fund my recommended work plan for the harbor. Unfortunately, the BOS have taken this process as far away from a sustainable outcome as humanly possible and at a significant financial burden to taxpayers.

Respectfully submitted,

Douglas Fay

APPENDIX C: WER SAMPLING REPORTS

APPENDIX C-1: WER SAMPLING EVENT 1 RESULTS SUMMARY: SUMMER DRY WEATHER, NEAP TIDE

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Southern California Coastal Water Research Project, Costa Mesa, CA

December 20, 2019

Introduction

For the Marina del Rey Harbor Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six WER sampling events over the course of one year. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the first WER event, which covers the dry weather neap tide condition.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MDRH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. This sampling was repeated once more such that a spatially-representative sample was taken during both flood and ebb tide. Once all sampling was complete, these two samples were composited to create one final sample per station. This sample was used for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, a subsample from all three locations within the basin was combined and the water quality parameters were measured in that sample. A duplicate sample for all parameters was taken at station MDRH-E. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 µm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4°C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis at SCCWRP. The qualitative DOC samples were brought back to the

laboratory and stored at 4°C overnight. The absorbance (at 340 nm) was measured the following day.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and run through the furnace to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile. For metals, one of each item (syringe, filter, and centrifuge tube) was sent to Physis to analyze as a blank sample. The syringe and centrifuge tube added no detectable copper. The filter blank contained 0.86 µg/L dissolved copper. By comparison, the field blank for this sampling event, which included the filter pre-rinse with DI water, contained no detectable copper.

For the toxicity testing, field samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. This stock was split between the SCCWRP and EcoAnalysts laboratories for the interlaboratory comparison. A working solution of 1000 µg Cu/L was made by each laboratory by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. A subsample of each dose was filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1°C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100. Survival was determined by dividing the sum of normal and abnormal embryos by the initial embryo count from the test start date and multiplying that number by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, v3.16.2.41) to calculate a predicted EC50 for *Mytilus* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the

BLM-based WER. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and calculate EC50 values for each station. These calculations were performed using CETIS (v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon (µg/L)	Field Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

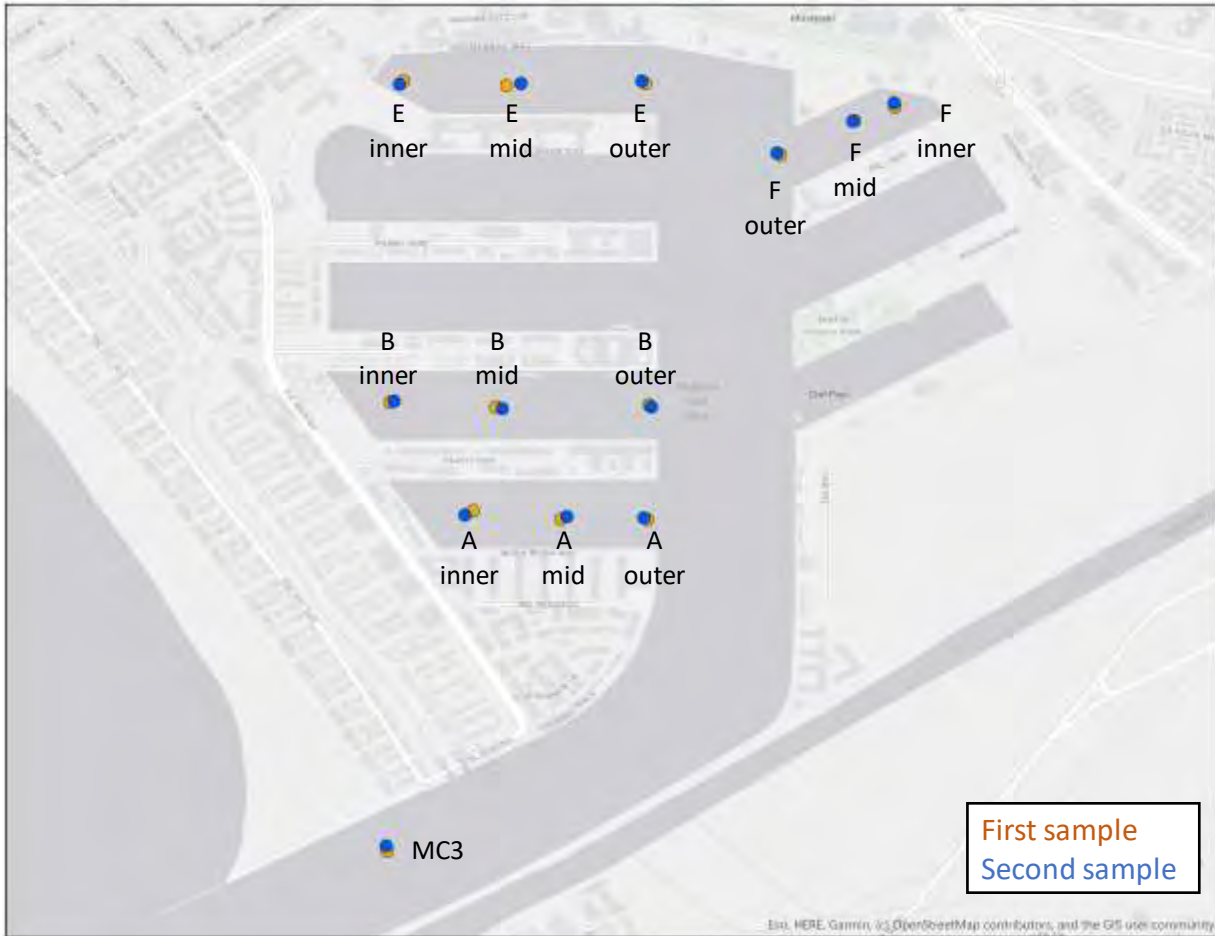


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Monday, August 26, 2019. This sampling event constituted the neap tide dry weather event. Sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA’s Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 35 minutes before the low tide (+0.23 ft) at +0.34 ft, and the final sample (MdrH-F) was taken approximately 2 hours before the high tide (+3.99 ft) at +3.24 ft. The overall tide change for the sampling window was +3.01 ft.

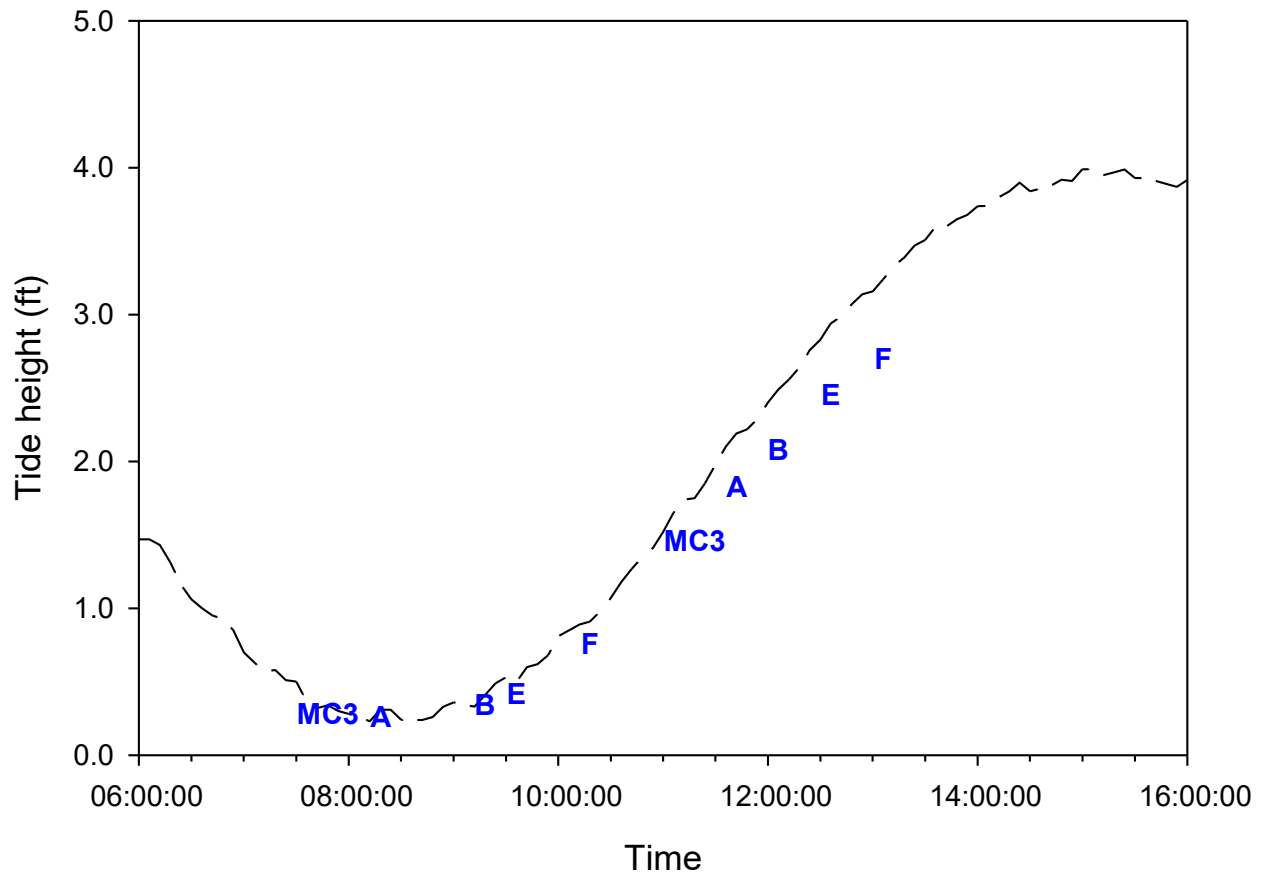


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Table 2. There were no consistent changes observed in water quality parameters by station location or time. Dissolved copper concentrations all exceeded the water quality criteria (3.1 $\mu\text{g/L}$) and ranged from 3.64 $\mu\text{g/L}$ (MdRH-MC3) to 9.55 $\mu\text{g/L}$ (MdRH-E dup). The lowest concentration was closest to the mouth of the harbor. Samples from the four basins were similar with no apparent spatial trend (i.e., back versus front basins). The range of copper concentrations among the basins was 7.10 $\mu\text{g/L}$ (MdRH-F) to 9.55 $\mu\text{g/L}$ (MdRH-E dup).

DOC concentrations tended to be lower in the outer main channel and front basins, compared to the two back basins. The DOC certified reference material was measured within the tolerance range, indicating accurate analytical technique. In addition to the quantitative analysis of DOC, a subsample (5-10 mL) of the filtrate was taken qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 3). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color.

$$\text{SAC340} = 2303 (\text{Abs}_{340}/\text{DOC})$$

Abs340 is the sample absorbance at 340 nm and DOC is the concentration in mg/L. All the samples had relatively similar absorbance values except for Basin F, which had the lowest absorbance and SAC340.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. Results and methods presented here were consistent with the QAPP, with two exceptions: 1) No matrix spike for DOC was analyzed. Although this requirement was inconsistent between the Work Plan (not required) and QAPP (required), efforts will be made to include this in future sampling events. 2) A thermometer was not included in the cooler of metals samples. However, these samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 5.4°C. These samples were kept under acceptable conditions during transit.

Table 2. Data collected from the WER #1 sampling event on August 26, 2019.

Station	Composite	Sample Start Time			Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)
		Inner	Mid	Outer										
MdRH-MC3	First	--	0737	--	0.34	8.15	34.0	23.0	7.31	0.942	4.38	3.64	19.6	18.4
MdRH-MC3	Second	--	1112	--	1.75	8.16	34.0	24.0	7.45					
MdRH-A	First	0800	0807	0812	0.30	8.05	34.2	23.8	6.72	0.914	9.15	8.37	42.1	40.8
MdRH-A	Second	1137	1144	1150	2.20	8.06	34.5	25.4	6.58					
MdRH-B	First	0907	0915	0921	0.42	8.07	34.2	25.2	6.71	0.957	8.21	7.38	39.4	39.3
MdRH-B	Second	1200	1207	1212	2.52	8.09	34.2	25.4	6.69					
MdRH-E	First	0937	0946	0954	0.66	8.08	34.1	25.5	6.59	1.04	9.18	7.82	63.5	62.8
MdRH-E	Second	1230	1240	1246	2.95	8.07	34.1	25.2	7.01					
MdRH-E Dup	First	0937	0946	0954	0.66	8.10	34.1	25.1	6.68	1.04	11.8	9.55	79.3	74.7
MdRH-E Dup	Second	1230	1240	1246	2.95	8.08	34.1	25.4	6.73					
MdRH-F	First	1006	1017	1022	0.92	8.06	34.1	25.4	6.44	1.06	9.01	7.10	48.6	45.8
MdRH-F	Second	1254	1301	1306	3.24	8.05	34.0	25.5	6.82					
QA Samples														
Tubing blank										0.377	ND	ND	2.48	1.52
Travel blank										--	ND	--	ND	--
Field blank										0.189	ND	ND	0.964	1.1
Filter blank 1										<0.055	--	--	--	--
Filter blank 2										0.234	--	--	--	--
Filter blank 3										<0.055	--	--	--	--
DOC CRM										0.858	within range			

Diss.-Dissolved
ND-Not detected

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

Dup-duplicate sample

Table 3. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	0.942	0.0040	8.56
MdRH-A	0.914	0.0029	7.31
MdRH-B	0.957	0.0038	9.14
MdRH-E	1.04	0.0037	8.21
MdRH-E Dup	1.04	0.0019	4.20
MdRH-F	1.06	0.0006	1.31
Granite Canyon	0.699	-0.0002	NC

NC=not calculated SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The toxicity test results met all test acceptability criteria with high survival and high normal development. Precision was good for all samples, with only one sample having a standard deviation greater than 10. One sample from the dose-response series for MdRH-E Dup (4 µg/L nominal concentration) was excluded from the dose-response and EC₅₀ calculations due to a suspected contamination of the sample used for the dissolved copper concentration analysis. The percent normal mussel embryos in the un-spiked samples (Granite Canyon and MdRH field samples) were all above 90%, indicating that, even though all the field samples had copper concentrations above the current water quality criteria (3.1 µg/L), no toxicity was observed. Dissolved copper concentrations measured in the dose-response samples and the corresponding toxicity test results (percent normal mussel embryos) are summarized in Table 4.

The dose-response curves and EC₅₀ values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 5). These values were then used to calculate water effect ratios using the Granite Canyon water EC₅₀ as the reference result (Table 5). The resulting WERs ranged from 1.21 (MdRH-E) to 1.36 (MdRH-F). MdRH-MC3 had the second lowest WER (1.28) which was equivalent to the average WER from Basin E. There was no apparent spatial trend in the calculated WERs. The geometric mean of the toxicity-based WERs was 1.31.

In addition to the toxicity-based WERs, the Biotic Ligand Model (BLM) was used to estimate EC₅₀ and WER values for each sample (Table 5). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC₅₀ results. Overall, the measured EC₅₀ values were higher than the BLM-predicted EC₅₀ values. This was true for both the sample water as well as the reference water. The BLM-based WERs ranged from 1.30 (MdRH-A) to 1.51 (MdRH-F), which was a larger range than the toxicity-based WERs. Similar to the trend observed for DOC concentration, the main channel and front basin WERs were lower than the back basin WERs. This result is consistent with expectations based on the structure of the BLM. The geometric mean of the BLM-WERs was 1.40.

Table 4. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
GC, 0 µg/L	0.132	91	3.1
GC, 4 µg/L	3.33	91	3.8
GC, 5.5 µg/L	4.36	93	1.7
GC, 7.0 µg/L	5.58	93	1.6
GC, 9.5 µg/L	7.26	83	4.0
GC, 13 µg/L	10.2	46	8.5
GC, 17 µg/L	12.9	8	4.9
GC, 23 µg/L	16.7	2	2.2
MdRH-MC3, 0 µg/L	3.39	91	2.4
MdRH-MC3, 3 µg/L	5.72	93	2.3
MdRH-MC3, 4 µg/L	6.12	91	2.0
MdRH-MC3, 5.5 µg/L	7.54	90	1.9
MdRH-MC3, 7.0 µg/L	8.62	81	4.9
MdRH-MC3, 9.5 µg/L	10.7	64	3.9
MdRH-MC3, 13 µg/L	13.7	34	8.3
MdRH-MC3, 17 µg/L	17.3	3	2.5
MdRH-A, 0 µg/L	7.91	92	2.1
MdRH-A, 3 µg/L	11	74	5.6
MdRH-A, 4 µg/L	11	69	4.5
MdRH-A, 5.5 µg/L	12.5	47	5.6
MdRH-A, 7.0 µg/L	13.8	40	9.5
MdRH-A, 9.5 µg/L	15.5	19	5.8
MdRH-A, 13 µg/L	18.9	2	0.9
MdRH-A, 17 µg/L	24.2	3	2.5
MdRH-B, 0 µg/L	6.95	91	2.0
MdRH-B, 3 µg/L	11.2	83	6.5
MdRH-B, 4 µg/L	10.5	73	8.8
MdRH-B, 5.5 µg/L	11.7	65	2.8
MdRH-B, 7.0 µg/L	13.9	46	6.6
MdRH-B, 9.5 µg/L	14.1	27	5.6
MdRH-B, 13 µg/L	21	4	3.0
MdRH-B, 17 µg/L	21.5	1	0.8
MdRH-E, 0 µg/L	6.77	92	1.6
MdRH-E, 3 µg/L	8.16	89	3.6
MdRH-E, 4 µg/L	9.11	81	6.7
MdRH-E, 5.5 µg/L	9.75	71	4.5
MdRH-E, 7.0 µg/L	11.1	57	3.9

Station and nominal copper spike	Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
MdRH-E, 9.5 µg/L	13	34	6.5
MdRH-E, 13 µg/L	15.3	13	5.8
MdRH-E, 17 µg/L	17.9	2	2.1
MdRH-E Dup, 0 µg/L	7.11	92	0.4
MdRH-E Dup, 3 µg/L	8.49	87	1.4
MdRH-E Dup, 4 µg/L	NA	80	4.9
MdRH-E Dup, 5.5 µg/L	11.4	67	5.3
MdRH-E Dup, 7.0 µg/L	12.7	58	5.4
MdRH-E Dup, 9.5 µg/L	13.8	39	4.8
MdRH-E Dup, 13 µg/L	17.4	16	2.3
MdRH-E Dup, 17 µg/L	20.6	3	3.2
MdRH-F, 0 µg/L	6.35	92	1.2
MdRH-F, 3 µg/L	8.87	80	22.9
MdRH-F, 4 µg/L	9.73	87	2.3
MdRH-F, 5.5 µg/L	10.8	75	3.6
MdRH-F, 7.0 µg/L	12.2	74	4.7
MdRH-F, 9.5 µg/L	13.7	48	5.4
MdRH-F, 13 µg/L	16.7	18	6.8
MdRH-F, 17 µg/L	19.4	1	1.1

NA=Not available; invalid result due to suspected contamination.

Table 5. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results		Biotic Ligand Model Predictions		
	Copper EC50 (µg/L)	Calculated WER	Copper EC50 (µg/L)	Calculated WER	
Granite Canyon	9.50		5.18		
MdRH-MC3	12.14	1.28	6.99	1.35	
MdRH-A	12.38	1.30	6.75	1.30	
MdRH-B	12.73	1.34	7.08	1.37	
MdRH-E	11.53	1.21	7.71	1.49	1.49 (mean)
MdRH-E duplicate	12.73	1.34		7.68	
MdRH-F	12.96	1.36	7.84	1.51	
Geometric mean		1.31		1.40	

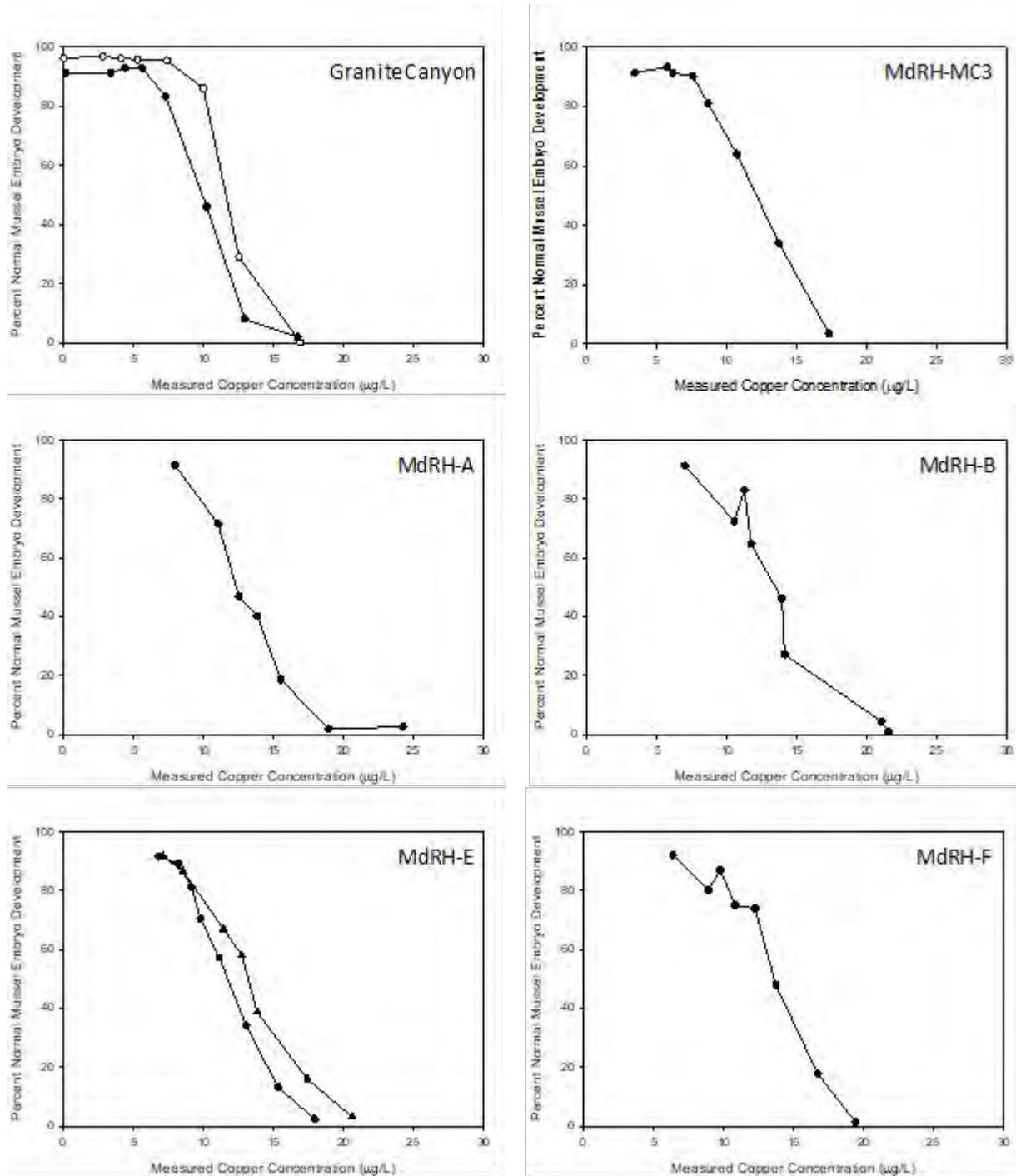


Figure 3. Dose response curves for reference water and field samples. Granite canyon results from SCCWRP (closed circles) and EcoAnalysts (open circles) are plotted together. MdrH-E (circles) and MdrH-E dup (triangles) are plotted together.

Granite Canyon Reference Water Comparison

Two laboratories performed the copper dose-response toxicity test using the Granite Canyon reference water: SCCWRP and EcoAnalysts. The reference water was sent directly from the Granite Canyon laboratory to each participant. SCCWRP made up the copper stock solution and sent a split sample with the spiking protocol to EcoAnalysts for use in their toxicity test. This ensured the same materials and methods were used. Additionally, EcoAnalysts ordered two batches of mussels from Taylor Shellfish Farms and sent one to SCCWRP to minimize organism variability. The dose response curves indicated a slightly higher EC50 for the Granite Canyon water test by EcoAnalysts (11.66 $\mu\text{g/L}$) compared to SCCWRP (9.50 $\mu\text{g/L}$). This difference can be seen in typical within-laboratory variability between tests.

Laboratory control charts and EC50 values from the literature provide some context on this variability. SCCWRP's copper reference toxicant test results from 2005 through 2018 resulted in EC50 values ranging from 5.80 $\mu\text{g/L}$ to 11.26 $\mu\text{g/L}$ (Figure 4). Copper reference toxicant tests performed at EcoAnalysts from 2007 through 2011 resulted in EC50 values ranging from 3.68 $\mu\text{g/L}$ to 14.05 $\mu\text{g/L}$ with a mean of 9.92 $\mu\text{g/L}$. Additionally, the EC50 data for *Mytilus spp.* cited in the USEPA's 2003 Draft Update of Ambient Water Quality Criteria for Copper, ranged from 3.75 $\mu\text{g/L}$ to 14.1 $\mu\text{g/L}$ (Table 1b of the 2003 USEPA document). The EC50 data for *Mytilus galloprovincialis* cited in the USEPA's 2016 Draft Aquatic Life Ambient Estuarine/Marine Water Quality Criteria for Copper, ranged from 3.56 $\mu\text{g/L}$ to 59.4 $\mu\text{g/L}$ (Table A-1 of the 2016 USEPA document).

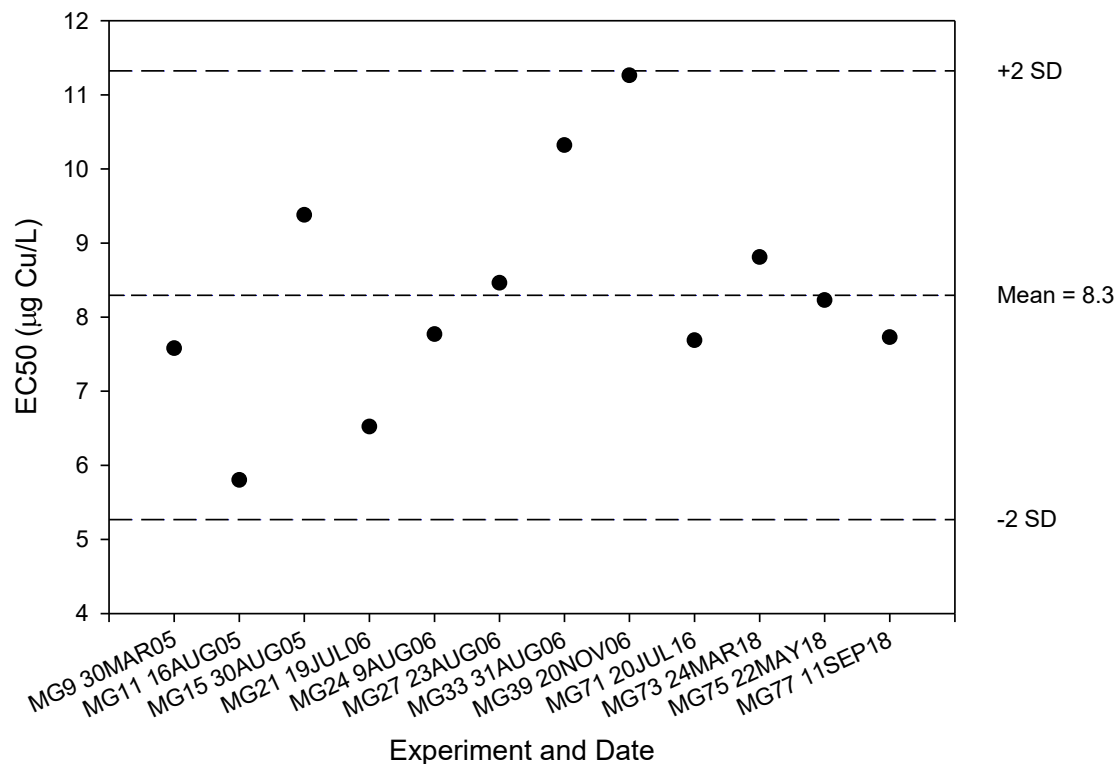


Figure 4. SCCWRP's copper reference toxicant control chart for *Mytilus galloprovincialis*. Please note, these EC50 values are based on nominal copper concentration.

References

Tait, T.N., Cooper, C.A., McGeer, J.C., Wood, C.M., Smith, D.S., 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.

USEPA, 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

USEPA 2003. 2003 Draft Update of Ambient Water Quality Criteria For Copper. EPA-822-R-03-026. Office of Water. Washington, DC.

USEPA 2016. Draft Aquatic Life Ambient Estuarine/Marine Water Quality Criteria For Copper – 2016. EPA-822-P-16-001. Office of Water. Washington, DC.

APPENDIX C-2: WER SAMPLING EVENT 2 RESULTS SUMMARY: SUMMER DRY WEATHER, SPRING TIDE

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February 3, 2020

Introduction

For the Marina del Rey Harbor Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six WER sampling events over the course of one year. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the second WER event, which covers the dry weather spring tide condition.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MdrH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. This sampling was repeated once more such that a spatially representative sample was taken during both flood and ebb tide. Once all sampling was complete, these two samples were composited to create one final sample per station. This sample was used for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, a subsample from all three locations within the basin was combined and the water quality parameters were measured in that sample. A duplicate sample for all parameters was taken at station MdrH-E. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 µm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4°C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis by Weck Laboratories, Inc. The qualitative DOC samples were brought back to the SCCWRP and the absorbance (at 340 nm) was measured the same day.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and run through the furnace to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile. For metals, one of each item from a batch (syringe, filter, and centrifuge tube) was sent to Physis to analyze as a blank sample. Physis rinsed each item with high purity laboratory water and analyzed the resulting samples. The syringe and centrifuge tube added no detectable copper. The filter blank contained 0.86 µg/L dissolved copper. By comparison, the field blank for this sampling event, which included the filter pre-rinse with DI water, contained very low levels of detectable copper (0.03 µg/L).

For the toxicity testing, field samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. A subsample of each dose was filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1°C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100. Survival was determined by dividing the sum of normal and abnormal embryos by the initial embryo count from the test start date and multiplying that number by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, Windward v3.16.2.41) to calculate a predicted EC50 for *Mytilus galloprovincialis* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the BLM-based WER. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and calculate EC50 values for each station. These calculations were performed using CETIS

(v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon (µg/L)	Field Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

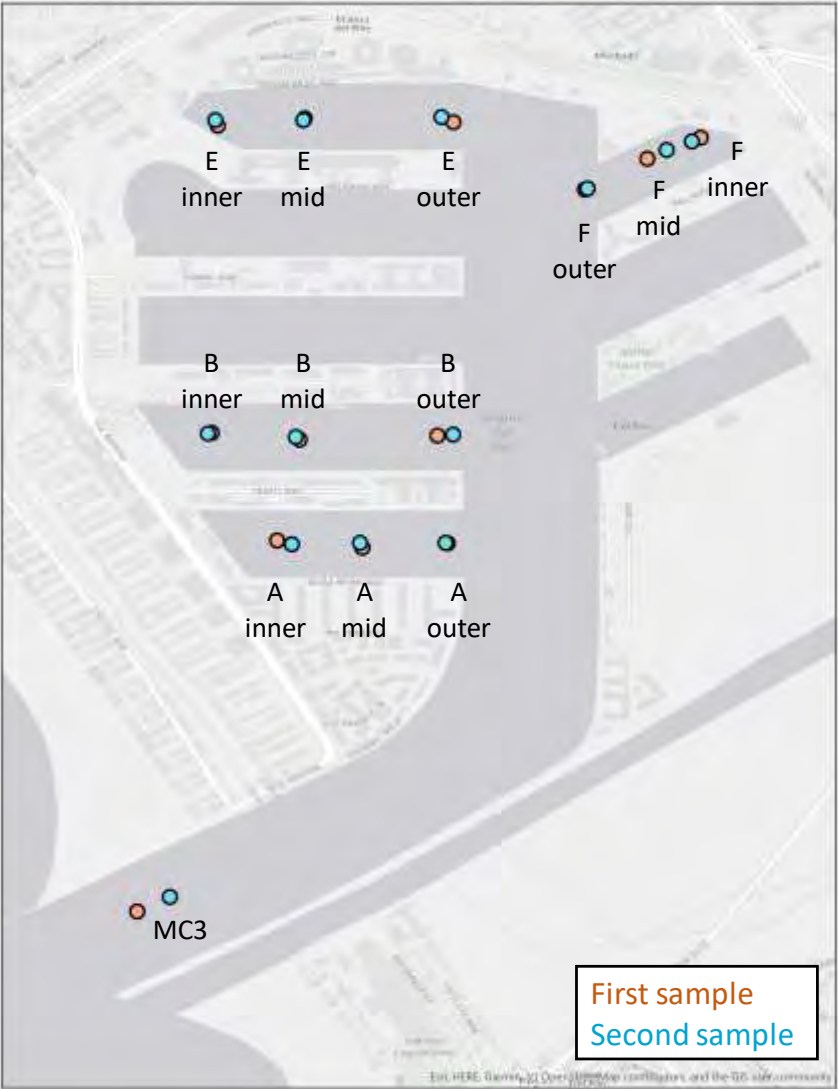


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Tuesday, October 1, 2019. This sampling event constituted the spring tide dry weather event. Sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA’s Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 90 minutes after the high tide (+5.33 ft) at +4.85 ft, and the final sample (MdrH-F) was taken approximately 80 minutes after the low tide (+1.19 ft) at +1.94 ft. The overall tide change for the sampling window was +3.65 ft.

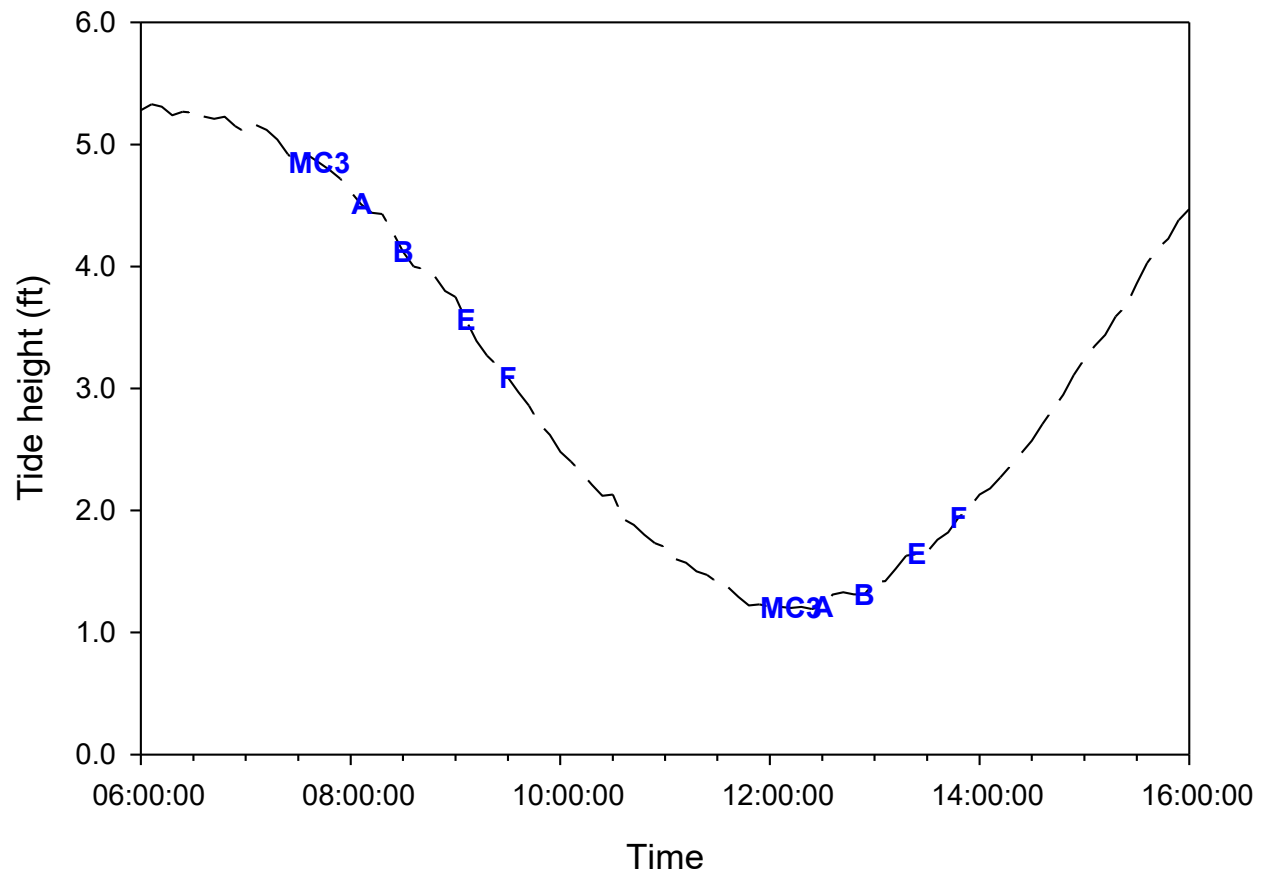


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Table 2. There were no consistent changes observed in water quality parameters by station location or time. Dissolved copper concentrations in all basin stations exceeded the water quality criteria (3.1 µg/L) and ranged from 5.27 µg/L (MdrH-F) to 6.54 µg/L (MdrH-A). Samples from the four basins were similar with no apparent spatial trend (i.e., back versus front basins). The lowest concentration was observed at MdrH-MC3 (1.78 µg/L) and was the only sample below the water quality criteria.

DOC concentrations were similar across all stations and only varied by 0.2 mg/L. These values are higher than those observed in the first WER event which may be due to the change in analytical laboratory for this sampling event. The DOC certified reference material was measured about 0.1 mg/L above the tolerance range, indicating a slight bias high. In addition to the quantitative analysis of DOC, a subsample (5-10 mL) of the filtrate was taken qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 3). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Based on the source and characterization of seven DOM isolates by Al-Reasi et al. (2012), they found SAC340 values for microbially-derived DOC in the range of 4-15, and terrestrially-derived DOC in the range of 28-40. These are not set thresholds for the two categories of DOC, but rather provide more context for data interpretation.

$$\text{SAC340} = 2303 (\text{Abs}_{340}/\text{DOC})$$

Abs₃₄₀ is the sample absorbance at 340 nm and DOC is the concentration in mg/L. All the Harbor samples had relatively similar absorbance values that fell into three groupings: Stations MC3, A, and E (0.0047-0.0051); B and E-dup (0.0060-0.0065), and F (0.0075). Granite Canyon had the lowest absorbance (0.0022) value. The resulting SAC340 values range from 5.39 (Granite Canyon) to 11.52 (MdrH-F), suggesting microbially-derived DOC.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. Results and methods presented here were consistent with the QAPP, with two exceptions: 1) No matrix spike for DOC was analyzed. Although this requirement was inconsistent between the Work Plan (not required) and QAPP (required), efforts will be made to include this in future sampling events. 2) A thermometer was not included in the cooler of metals samples. However, these samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 1.4°C. These samples were kept under acceptable conditions during transit.

Table 2. Data collected from the WER #2 sampling event on October 1, 2019.

Station	Composite	Sample Start Time			Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)
		Inner	Mid	Outer										
MdRH-MC3	First	--	0741	--	4.82	8.13	33.3	19.8	7.20	1.4	2.39	1.78	9.48	8.87
MdRH-MC3	Second	--	1209	--	1.20	8.18	33.3	21.2	7.76					
MdRH-A	First	0805	0812	0818	4.40	8.06	33.5	20.6	6.12	1.4	8.06	6.54	37.9	35.4
MdRH-A	Second	1228	1236	1241	1.27	8.07	33.4	23.1	6.47					
MdRH-B	First	0830	0838	0845	4.00	8.07	33.5	21.0	6.08	1.4	7.22	5.61	36.2	34.0
MdRH-B	Second	1253	1301	1307	1.41	8.04	33.4	23.4	6.33					
MdRH-E	First	0903	0911	0919	3.38	8.00	33.5	22.1	5.35	1.6	9.38	6.09	69.5	64.5
MdRH-E	Second	1323	1331	1337	1.73	7.97	33.4	24.2	5.76					
MdRH-E Dup	First	0903	0911	0919	3.38	7.96	33.3	21.9	5.70	1.5	8.81	5.96	65.7	62.7
MdRH-E Dup	Second	1323	1331	1337	1.73	7.97	33.2	24.1	5.77					
MdRH-F	First	0930	0935	0939	2.98	8.08	33.5	22.0	6.22	1.5	8.12	5.27	40.7	36.4
MdRH-F	Second	1348	1354	1359	2.06	8.10	33.5	23.1	6.75					
QA Samples														
Tubing blank										0.46	0.6	0.02	1.18	0.18
Travel blank										--	ND	--	0.14	--
Field blank										ND	ND	0.03	0.03	0.10
Filter blank 1										ND	--	--	--	--
Filter blank 2										ND	--	--	--	--
Filter blank 3										ND	--	--	--	--
DOC CRM										0.98	above range (0.85-0.90)			

Diss.-Dissolved
ND-Not detected

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

Dup-duplicate sample

Table 3. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	1.4	0.0047	7.73
MdRH-A	1.4	0.0051	8.39
MdRH-B	1.4	0.0060	9.87
MdRH-E	1.6	0.0050	7.20
MdRH-E Dup	1.5	0.0065	9.98
MdRH-F	1.5	0.0075	11.52
Granite Canyon	0.94	0.0022	5.39

NC=not calculated SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The toxicity test results met all test acceptability criteria with high survival and high normal development. Precision was good for all samples, with most samples having a standard deviation less than 10 and all below 20. The percent normal mussel embryos in the un-spiked samples (Granite Canyon and MdRH field samples) were all above 90%, indicating that, even though all the basin samples had copper concentrations above the current water quality criteria (3.1 µg/L), no toxicity was observed. Dissolved copper concentrations measured in the dose-response samples and the corresponding toxicity test results (percent normal mussel embryos) are summarized in Table 4.

The dose-response curves and EC₅₀ values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 5). These values were then used to calculate water effect ratios using the Granite Canyon water EC₅₀ as the reference result (Table 5). The resulting WERs ranged from 1.33 (MdRH-MC3) to 1.46 (MdRH-E). There was a slight spatial trend observed with lower WERs in the main channel and front basins (1.33-1.35) compared to the back basins (1.41-1.46). The geometric mean of the toxicity-based WERs was 1.39.

In addition to the toxicity-based WERs, the Biotic Ligand Model (BLM) was used to estimate EC₅₀ and WER values for each sample (Table 5). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC₅₀ results. Overall, the measured EC₅₀ values were higher than the BLM-predicted EC₅₀ values. This was true for both the sample water as well as the reference water. The BLM-based WERs ranged from 1.48 (MdRH-A) to 1.70 (MdRH-E), which was a larger range than the toxicity-based WERs. Similar to the trend observed for DOC concentration and the toxicity-based WERs, the main channel and front basin WERs were lower than the back basin WERs. This result is consistent with expectations based on the structure of the BLM. The geometric mean of the BLM-WERs was 1.55.

Table 4. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
GC, 0 µg/L	0.042	96	1.4
GC, 4 µg/L	3.43	96	1.1
GC, 5.5 µg/L	4.66	95	1.3
GC, 7.0 µg/L	6.06	93	1.8
GC, 9.5 µg/L	8.14	65	7.3
GC, 13 µg/L	11.4	21	15.3
GC, 17 µg/L	14.7	5	2.6
GC, 23 µg/L	20.0	1	0.8
MdRH-MC3, 0 µg/L	1.71	94	2.8
MdRH-MC3, 3 µg/L	3.89	97	1.2
MdRH-MC3, 4 µg/L	4.74	96	3.1
MdRH-MC3, 5.5 µg/L	5.98	95	1.5
MdRH-MC3, 7.0 µg/L	9.15	95	1.8
MdRH-MC3, 9.5 µg/L	8.75	86	5.8
MdRH-MC3, 13 µg/L	11.5	61	12.2
MdRH-MC3, 17 µg/L	15.2	8	4.0
MdRH-A, 0 µg/L	5.55	94	0.6
MdRH-A, 3 µg/L	7.83	92	1.7
MdRH-A, 4 µg/L	8.64	93	1.5
MdRH-A, 5.5 µg/L	9.97	84	4.4
MdRH-A, 7.0 µg/L	11.3	68	10.7
MdRH-A, 9.5 µg/L	13.3	34	8.2
MdRH-A, 13 µg/L	15.9	8	5.4
MdRH-A, 17 µg/L	19.4	3	1.9
MdRH-B, 0 µg/L	5.08	95	1.7
MdRH-B, 3 µg/L	7.05	95	2.1
MdRH-B, 4 µg/L	7.90	94	1.8
MdRH-B, 5.5 µg/L	9.12	92	1.5
MdRH-B, 7.0 µg/L	10.2	76	6.8
MdRH-B, 9.5 µg/L	11.8	54	14.7
MdRH-B, 13 µg/L	14.8	22	11.8
MdRH-B, 17 µg/L	18.1	4	2.9
MdRH-E, 0 µg/L	5.32	94	3.8
MdRH-E, 3 µg/L	7.37	94	1.4
MdRH-E, 4 µg/L	8.04	95	1.6
MdRH-E, 5.5 µg/L	9.05	92	2.0
MdRH-E, 7.0 µg/L	10.2	77	5.6

Station and nominal copper spike	Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
MdRH-E, 9.5 µg/L	12.4	66	19.7
MdRH-E, 13 µg/L	15.3	32	5.8
MdRH-E, 17 µg/L	18.6	2	1.0
MdRH-E Dup, 0 µg/L	5.43	96	1.4
MdRH-E Dup, 3 µg/L	7.57	94	1.0
MdRH-E Dup, 4 µg/L	8.27	93	2.1
MdRH-E Dup, 5.5 µg/L	9.31	88	2.2
MdRH-E Dup, 7.0 µg/L	11.6	79	5.0
MdRH-E Dup, 9.5 µg/L	12.8	44	7.8
MdRH-E Dup, 13 µg/L	15.4	19	4.4
MdRH-E Dup, 17 µg/L	18.7	3	2.8
MdRH-F, 0 µg/L	4.72	95	1.9
MdRH-F, 3 µg/L	7.00	94	1.1
MdRH-F, 4 µg/L	7.68	95	1.2
MdRH-F, 5.5 µg/L	8.77	94	1.1
MdRH-F, 7.0 µg/L	10.7	87	5.6
MdRH-F, 9.5 µg/L	11.9	67	7.3
MdRH-F, 13 µg/L	14.7	23	4.8
MdRH-F, 17 µg/L	18.0	7	7.1

Table 5. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results		Biotic Ligand Model Predictions		
	Copper EC50 (µg/L)	Calculated WER	Copper EC50 (µg/L)	Calculated WER	
Granite Canyon	9.02		6.96		
MdRH-MC3	11.99	1.33	10.35	1.49	
MdRH-A	12.18	1.35	10.32	1.48	
MdRH-B	12.22	1.35	10.34	1.49	
MdRH-E	13.17	1.46	11.81	1.70	1.65 (mean)
MdRH-E duplicate	12.69	1.41		11.09	
MdRH-F	12.97	1.44	11.06	1.59	
Geometric mean		1.39		1.55	

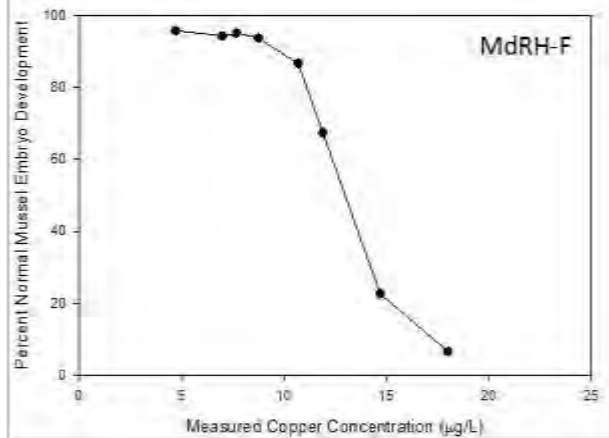
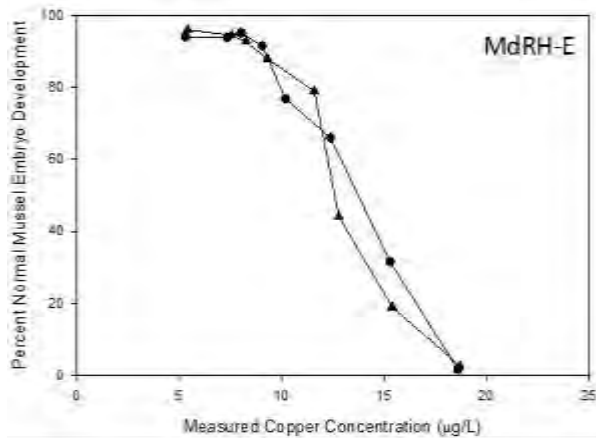
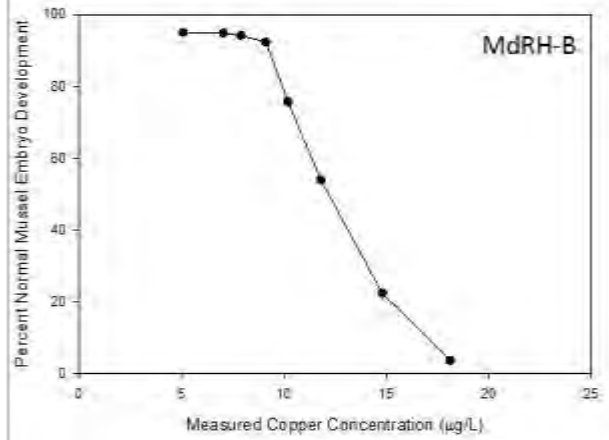
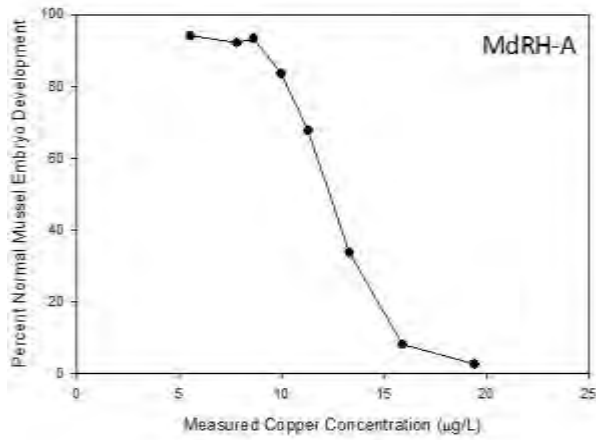
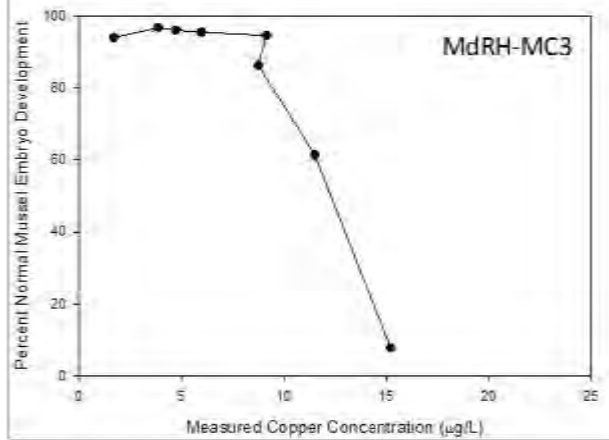
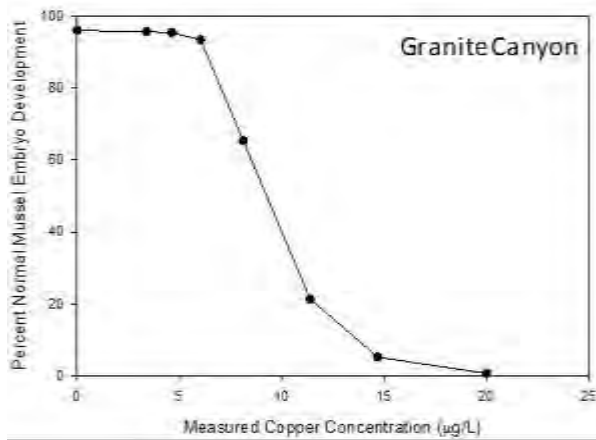


Figure 3. Dose response curves for reference water and field samples. MdRH-E (circles) and MdRH-E dup (triangles) are plotted together.

References

- Al-Reasi, H.A. and D.S. Smith. 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.
- Tait, T.N., C.A Cooper, J.C. McGeer, C.M. Wood, and D.S. Smith. 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.
- USEPA. 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

APPENDIX C-3: WER SAMPLING EVENT 3 RESULTS SUMMARY: WET WEATHER

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March 13, 2020

Introduction

For the Marina del Rey Harbor (MdrRH) Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six WER sampling events over the course of one year. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the third WER event, which covers the first wet weather sampling event.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MdrRH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. Unlike the previous dry weather sampling events, this sampling was focused on rainfall and did not include composites based on the tidal cycle. The spatial composite samples were subsampled for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, a subsample from all three locations within the basin was combined and the water quality parameters were measured in that sample. Surface water salinity measurements were recorded at each subsample location to identify any potential salinity gradients due to the recent wet weather. A duplicate sample for all parameters was taken at station MdrRH-MC3. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 µm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4°C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis at SCCWRP. The qualitative DOC samples were brought back to the laboratory and the absorbance (at 340 nm) was measured the same day.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and kilned to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile. For metals, one of each item (syringe, filter, and centrifuge tube) was sent to Physis to analyze as a blank sample. Physis rinsed each item with high purity laboratory water and analyzed the resulting samples. The syringe and centrifuge tube added no detectable copper. The filter blank contained 0.86µg/L dissolved copper. By comparison, the field blank for this sampling event, which included the filter pre-rinse with DI water, contained no detectable copper.

For the toxicity testing, field samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. A subsample of each dose was filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1°C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, Windward v3.16.2.41) to calculate a predicted EC50 for *Mytilus galloprovincialis* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the BLM-based WER. These calculations provide a comparison between the model and laboratory-based results. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and calculate EC50 values for each station. These calculations were performed using CETIS (v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the

Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon (µg/L)	Field Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

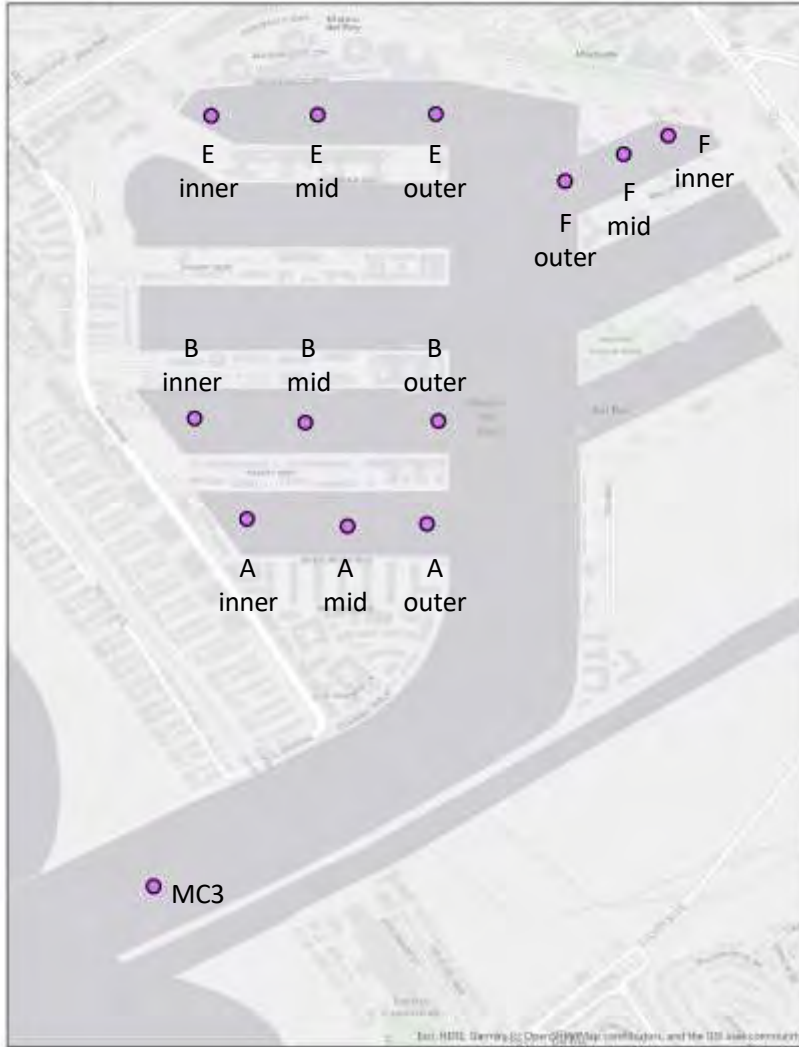


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Thursday, December 5, 2019. This sampling event constituted the first wet weather sample collection. The trigger for a wet weather event is a minimum of 0.5 inches of rain. For this event, a storm on December 4, 2019 produced approximately 1.15 inches of rain after a dry antecedent period of five days. The previous storm on November 27 through 29 produced approximately 1.33 inches of rain. This data was obtained from the Los Angeles County Public Works precipitation map and rain gauge data website (<https://dpw.lacounty.gov/wrd/rainfall/#>). The Ballona Creek rain gauge provided the closest location to the Harbor. Appendix A includes the results of wet weather sampling performed in early 2019 which evaluated the changes in salinity over time after a storm event.

Although tidal compositing was not performed during this sample event, the spatial composite samples taken at each location were related to tide height using the sample start time and the tide

height based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 75 minutes after the low tide (+1.32 ft) at +1.63 ft, and the final sample (MdrH-F) was taken approximately 3 hours after the low tide and 4 hours before the high tide (+4.86 ft) at +2.79 ft. The overall tide change for the sampling window was +1.16 ft.

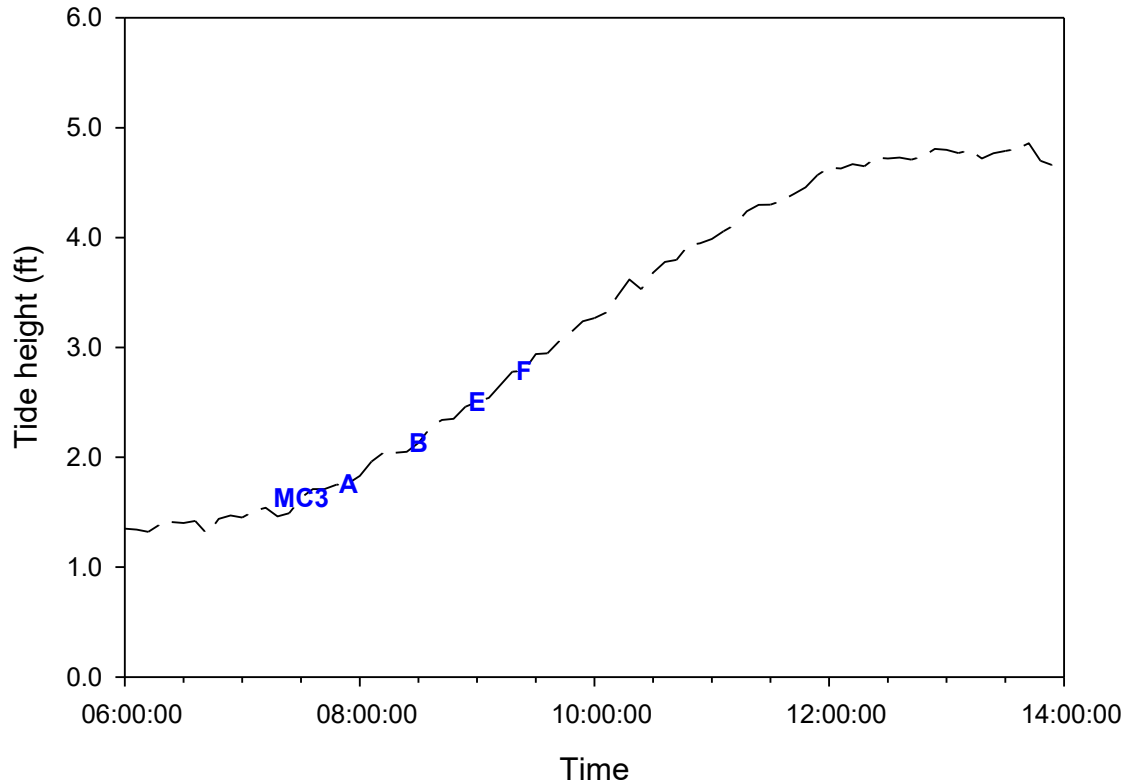


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Table 2. The pH at the MdrH-MC station was elevated relative to the basin station locations by approximately 0.20-0.25 pH units. Salinity at the 1 m sampling depth was reduced by approximately 1-3 ppt, relative to previous dry weather sampling events in August and October. There was little variation in salinity among station locations. Additional salinity measurements were taken in the surface water at each subsample location (Table 3). The probes were placed into the water over the side of the boat until deep enough to submerge the probe and obtain a reading. No spatial gradient was observed in basins A or B; however, a salinity gradient was observed for Basins E and F. Basin E exhibited a gradient from lower to higher salinity moving from the inner to outer basin. All stations had reduced salinity in the surface water compared to the sample depth 1m below.

Dissolved copper concentrations in all basin stations exceeded the water quality criteria (3.1 µg/L) and ranged from 10.2 µg/L (MdrRH-B) to 12.9 µg/L (MdrRH-E). Basins A and E had similar dissolved copper concentrations which were slightly higher than those measured in Basins B and F. When compared to results from the first two dry weather WER sampling events, these wet weather dissolved copper concentrations are 1.5-2 times higher. The lowest concentration during this sampling event was observed at MdrRH-MC3 (0.82 µg/L), with a similar value for MdrRH-MC dup (1.13 µg/L). These two were the only samples below the water quality criteria.

Wet weather DOC concentrations had a higher range in values (1.24-1.58 mg/L) compared to the previous MdrRH dry weather samples tested by SCCWRP with an overall difference of 0.34 mg/L. The results also showed a spatial trend with the front basins (A and B) having higher DOC concentrations relative to the back basins (E and F). DOC concentrations at MdrRH-MC were intermediate. The DOC certified reference material was measured within the acceptable range.

In addition to the quantitative analysis of DOC, a subsample (5-10 mL) of the filtrate was taken for qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 4). Typically, more aromatic, terrestrially derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Based on the source and characterization of seven DOM isolates by Al-Reasi et al. (2012), they found SAC340 values for microbially-derived DOC in the range of 4-15, and terrestrially derived DOC in the range of 28-40. These are not set thresholds for the two categories of DOC, but rather provide more context for data interpretation.

$$\text{SAC340} = 2303 (\text{Abs}_{340}/\text{DOC})$$

Abs₃₄₀ is the sample absorbance at 340 nm and DOC is the concentration in mg/L. All the Harbor samples had relatively similar absorbance values except for MdrRH-E, which had the highest absorbance value (0.0126). This may be due to more terrestrial runoff following the rain event. The resulting SAC340 values range from 11.06 (MdrRH-MC3 dup) to 23.40 (MdrRH-E), which are higher than measured in previous sampling events. About half of the samples have SAC340 values around the high end of the reported microbially-derived DOC range, with the other half in the unspecified range (15-28) between the microbial and terrestrial categories. The overall increase in SAC340 values in wet weather could indicate a shift to more terrestrially derived DOC relative to the dry sampling event results.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. The salinity probe failed during the sample collection at the final station, Basin F, resulting in no salinity field measurement for that location. Attempts to repair the probe in the field were unsuccessful. Therefore, salinity samples were returned to the laboratory for analysis. This deficiency did not materially affect the outcome of the study.

Results and methods presented here were consistent with the QAPP, with two exceptions: 1) No matrix spike for DOC was analyzed. Although this requirement was inconsistent between the Work Plan (not required) and QAPP (required), efforts will be made to include this in future

sampling events. 2) A thermometer was not included in the cooler of metals samples. These samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 2.0 °C indicating these samples were kept under acceptable conditions during transit.

Table 2. Data collected from the WER #3 sampling event on December 5, 2019.

Station	Sample Start Time			Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)	
	Inner	Mid	Outer											
MdRH-MC3	--	0728	--	1.63	8.31	32.2	15.0	7.75	1.32	1.55	0.821	7.83	6.08	
MdRH-MC3 Dup	--	0728	--	1.63	8.27	32.0	15.2	7.71	1.46	1.98	1.13	10.3	9.57	
MdRH-A	0755	0806	0814	1.90	8.03	31.6	15.9	6.65	1.58	14.1	12.7	67.3	67.2	
MdRH-B	0827	0834	0841	2.25	8.04	30.9	16.1	6.60	1.50	11.9	10.2	57.7	55.9	
MdRH-E	0857	0904	0911	2.54	7.98	31.7	16.6	6.34	1.24	14.7	12.9	85.1	85.0	
MdRH-F	0921	0927	0932	2.84	8.02	30.4*	16.3	6.38	1.27	11.7	10.4	57.3	58.3	
QA Samples														
Tubing blank										< 0.055	ND	ND	ND	ND
Travel blank										--	ND	--	ND	--
Field blank										< 0.055	ND	ND	ND	ND
Filter blank 1										< 0.055	--	--	--	--
Filter blank 2										< 0.055	--	--	--	--
Filter blank 3										< 0.055	--	--	--	--
DOC CRM										0.856	within range (0.85-0.90)			

Diss.-Dissolved
ND-Not detected

DO-Dissolved oxygen

DOC-Dissolved organic carbon

*MdRH-F salinity measured in the laboratory due to failure of field probe

Zn-Zinc

Cu-Copper

Dup-duplicate sample

Table 3. Surface water salinity field measurements.

Station	Inner	Mid	Outer
MdRH-MC3	--	29.0	--
MdRH-A	29.7	30.0	29.8
MdRH-B	28.6	29.0	28.2
MdRH-E	23.1	25.1	28.4
MdRH-F	29.0	27.7	NM

NM= not measured due to probe failure

Table 4. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	1.32	0.0098	17.10
MdRH-MC3 dup	1.46	0.0070	11.06
MdRH-A	1.58	0.0083	12.11
MdRH-B	1.50	0.0092	14.17
MdRH-E	1.24	0.0126	23.40
MdRH-F	1.27	0.0083	15.11
Granite Canyon	1.00	0.0073	16.85

SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The toxicity test results met all test acceptability criteria for survival ($\geq 50\%$) and normal development ($\geq 90\%$) in the Granite Canyon control. Precision was measured by sample standard deviation, with most samples having a standard deviation less than 10% and all below 25%. The percent normal mussel embryos in the un-spiked samples (Granite Canyon and MdRH field samples) were all above 90%, indicating that, even though all the basin samples had copper concentrations above the current water quality criteria (3.1 $\mu\text{g/L}$), no toxicity was observed. Dissolved copper concentrations measured in the dose-response samples and the corresponding toxicity test results (percent normal mussel embryos) are summarized in Table 5.

The dose-response curves and EC₅₀ values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 6). These values were then used to calculate water effect ratios using the Granite Canyon water EC₅₀ as the reference result (Table 6). EC₅₀ values could not be calculated for MdRH-MC3 and -MC3 dup as the toxicity did not reach 50% at the highest copper spike concentration. The dose-response results for MdRH-MC3 provide an estimate of the EC₅₀ as $> 13.6 \mu\text{g/L}$. No WERs were calculated for these samples. For the basins, the WERs ranged from 1.54 (MdRH-A) to 1.59 (MdRH-B and -E). There was no spatial trend observed between

front and back basins, with minimal variability between the samples. The geometric mean of the toxicity based WERs in the basins was 1.57.

In addition to the toxicity based WERs, the Biotic Ligand Model (BLM) was used to estimate EC50 and WER values for each sample (Table 6). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC50 results. Similar to the WER results from the first and second sampling events, the measured EC50 values were higher than the BLM-predicted EC50 values. This was true for both the sample water as well as the reference water. The BLM-based WERs ranged from 1.23 (MdRH-E) to 1.56 (MdRH-A), which was a larger range (0.33) than the toxicity-based WERs (0.05). Similar to the trend observed for DOC concentration, the front basin WERs were higher than the back basin WERs, consistent with expectations of the BLM that additional DOC will reduce toxicity. The geometric mean of the wet weather BLM-WERs was 1.38.

Table 5. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
GC, 0 µg/L	0.187	96	2.0
GC, 4 µg/L	3.86	95	0.6
GC, 5.5 µg/L	4.56	96	1.8
GC, 7.0 µg/L	5.83	96	1.3
GC, 9.5 µg/L	7.74	92	2.6
GC, 13 µg/L	11.1	29	8.4
GC, 17 µg/L	14.4	3	1.7
GC, 23 µg/L	19.7	5	1.9
MdRH-MC3, 0 µg/L	0.749	97	0.9
MdRH-MC3, 3 µg/L	2.98	96	0.5
MdRH-MC3, 4 µg/L	3.73	96	1.5
MdRH-MC3, 5.5 µg/L	4.68	97	1.0
MdRH-MC3, 7.0 µg/L	5.76	96	1.6
MdRH-MC3, 9.5 µg/L	7.75	97	0.5
MdRH-MC3, 13 µg/L	10.6	94	1.1
MdRH-MC3, 17 µg/L	13.6	54	13.8
MdRH-MC3 dup, 0 µg/L	1.08	96	1.9
MdRH-MC3 dup, 3 µg/L	3.04	96	1.1
MdRH-MC3 dup, 4 µg/L	3.97	97	1.0
MdRH-MC3 dup, 5.5 µg/L	4.82	98	0.7
MdRH-MC3 dup, 7.0 µg/L	5.67	96	1.2
MdRH-MC3 dup, 9.5 µg/L	7.69	97	1.2
MdRH-MC3 dup, 13 µg/L	10.4	95	0.2

Station and nominal copper spike	Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
MdRH-MC3 dup, 17 µg/L	13.3	73	9.1
MdRH-A, 0 µg/L	11.5	95	1.3
MdRH-A, 3 µg/L	13.3	89	2.1
MdRH-A, 4 µg/L	13.6	71	12.0
MdRH-A, 5.5 µg/L	15.3	57	5.5
MdRH-A, 7.0 µg/L	16.2	29	6.6
MdRH-A, 9.5 µg/L	18.4	9	6.2
MdRH-A, 13 µg/L	21.0	7	4.9
MdRH-A, 17 µg/L	24.7	4	1.3
MdRH-B, 0 µg/L	9.17	97	0.8
MdRH-B, 3 µg/L	10.8	96	1.2
MdRH-B, 4 µg/L	11.5	94	1.7
MdRH-B, 5.5 µg/L	12.7	91	6.2
MdRH-B, 7.0 µg/L	14.0	77	3.1
MdRH-B, 9.5 µg/L	16.1	43	8.0
MdRH-B, 13 µg/L	19.2	10	6.9
MdRH-B, 17 µg/L	22.3	7	2.7
MdRH-E, 0 µg/L	11.5	95	2.2
MdRH-E, 3 µg/L	12.9	90	4.6
MdRH-E, 4 µg/L	14.0	78	3.4
MdRH-E, 5.5 µg/L	14.7	66	7.8
MdRH-E, 7.0 µg/L	16.5	43	23.7
MdRH-E, 9.5 µg/L	18.4	12	3.6
MdRH-E, 13 µg/L	21.1	4	2.8
MdRH-E, 17 µg/L	24.5	5	1.4
MdRH-F, 0 µg/L	9.28	96	1.6
MdRH-F, 3 µg/L	11.5	94	1.7
MdRH-F, 4 µg/L	12.3	94	1.7
MdRH-F, 5.5 µg/L	13.2	79	9.1
MdRH-F, 7.0 µg/L	14.4	90	1.8
MdRH-F, 9.5 µg/L	16.2	30	8.5
MdRH-F, 13 µg/L	18.9	8	4.3
MdRH-F, 17 µg/L	22.4	4	2.8

Table 6. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results		Biotic Ligand Model Predictions		
	Copper EC50 (µg/L)	Calculated WER	Copper EC50 (µg/L)	Calculated WER	
Granite Canyon	9.93		7.41		
MdRH-MC3 ^a	> 13.6	--	9.79	1.32	1.39
MdRH-MC3 duplicate ^a	--	--	10.77	1.45	(mean)
MdRH-A	15.33	1.54	11.59	1.56	
MdRH-B	15.75	1.59	10.97	1.48	
MdRH-E	15.77	1.59	9.09	1.23	
MdRH-F	15.58	1.57	9.32	1.26	
Geometric mean		1.57 (basins only)		1.38 ^b (basins only)	

^aEC50 values could not be calculated due to low toxicity in dose-response range.

^bThe geometric mean for all locations (basins and main channel) is also 1.38.

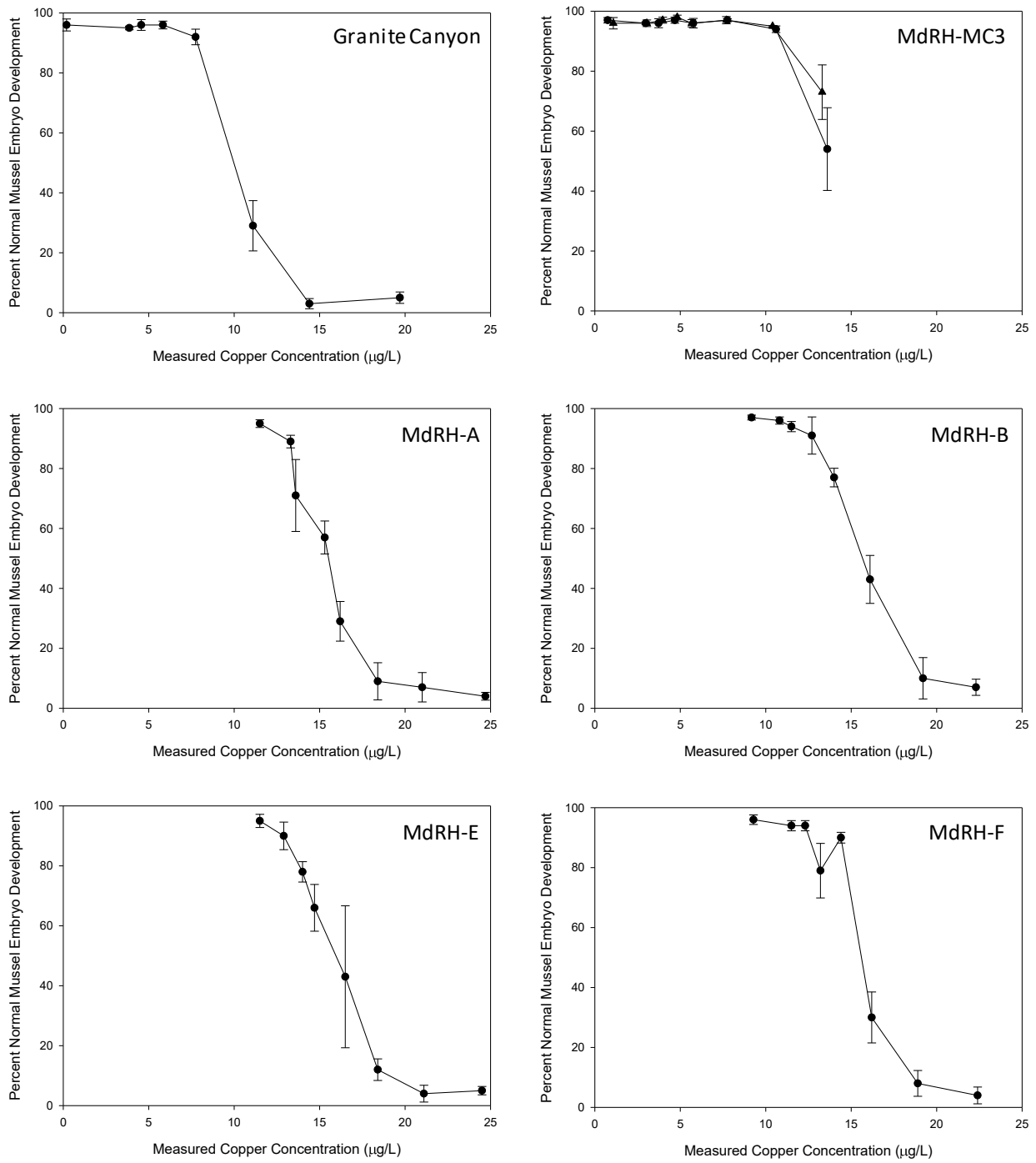


Figure 3. Dose response curves for reference water and field samples. MdRH-MC3 (circles) and MdRH-MC3 dup (triangles) are plotted together.

References

Al-Reasi, H.A., Smith, D.S., 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.

Tait, T.N., Cooper, C.A., McGeer, J.C., Wood, C.M., Smith, D.S., 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.

USEPA, 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

APPENDIX C-4: WER SAMPLING EVENT 4 RESULTS SUMMARY: WINTER DRY WEATHER, SPRING TIDE

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June 8, 2020

Introduction

For the Marina del Rey Harbor Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six WER sampling events over the course of one year. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the fourth WER event, which covers the winter dry weather, spring tide sampling event.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MDRH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. This sampling was repeated once more such that a spatially representative sample was taken during both flood and ebb tide. Once all sampling was complete, these two samples were composited to create one final sample per station. This sample was subsampled for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, water quality parameters were measured at each subsample location (inner, mid, and outer). A duplicate sample for all parameters was taken at station MDRH-MC3. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 µm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4 °C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis at SCCWRP. The qualitative DOC samples were brought back to the laboratory and the absorbance (at 340 nm) was measured within 24 hours of sample filtration.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and kilned to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile. A new batch of supplies was ordered, and, as such, one of each item (syringe, filter, and centrifuge tube) was sent to Physis to analyze as a blank sample for metals. Physis rinsed each item with high purity laboratory water and analyzed the resulting samples. The syringe, centrifuge tube, and filter blank samples contained 0.05 µg/L, 0.11 µg/L, and 0.18 µg/L total copper, respectively. The copper concentrations in the syringe (0.05 µg/L) and centrifuge tube (0.11 µg/L) were elevated compared to the blank analyses from the first batch (no detectable copper for both). Copper concentration in the filter blank (0.11 µg/L) was lower than the first filter blank (0.86 µg/L).

For the toxicity testing, field samples were run through a 100-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. Subsamples of each dose from day 0 and day 2 were filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1°C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, Windward v3.16.2.41) to calculate a predicted EC50 for *Mytilus galloprovincialis* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the BLM-based WER. These calculations provide a comparison between the model and laboratory-based results. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and

calculate EC50 values for each station. These calculations were performed using CETIS (v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon and MC3 samples (µg/L)	Basin Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

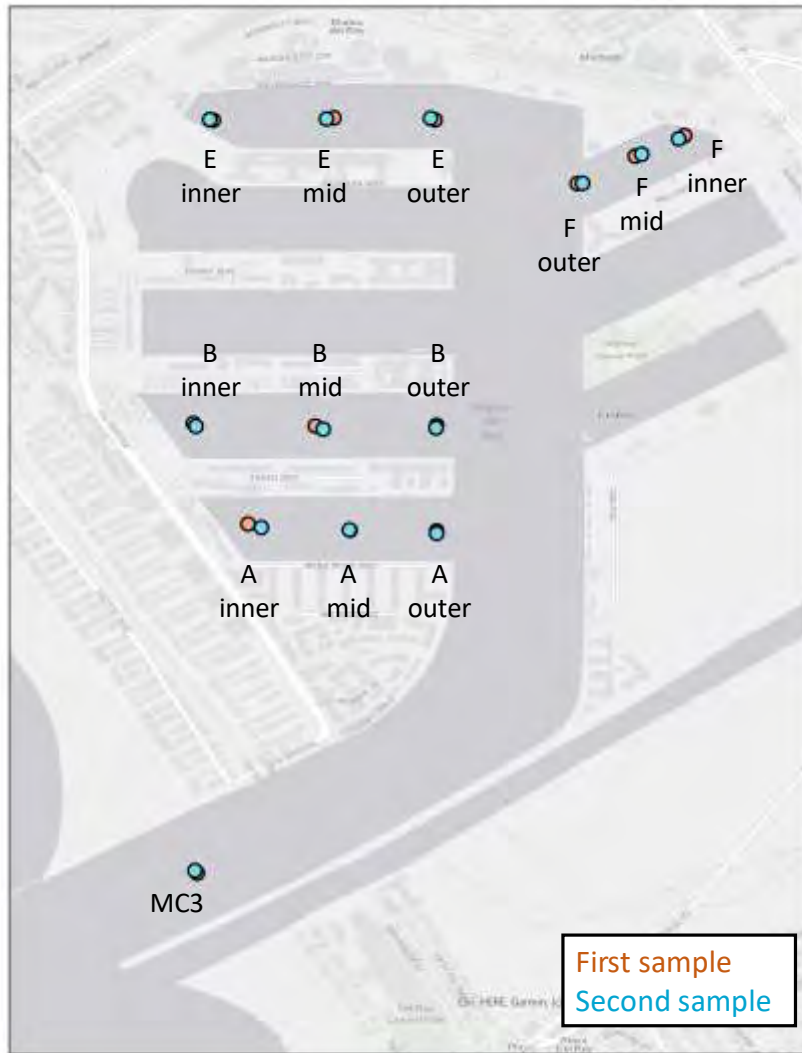


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Thursday, March 5, 2020. This sampling event constituted the winter dry weather, spring tide sample collection. Sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 2 hours after the high tide (+5.27 ft) at +4.47 ft, and the final sample (MdrH-F) was taken approximately 2.75 hours after the low tide (-0.33 ft) at +1.41 ft. The overall tide change for the sampling window was +4.80 ft.

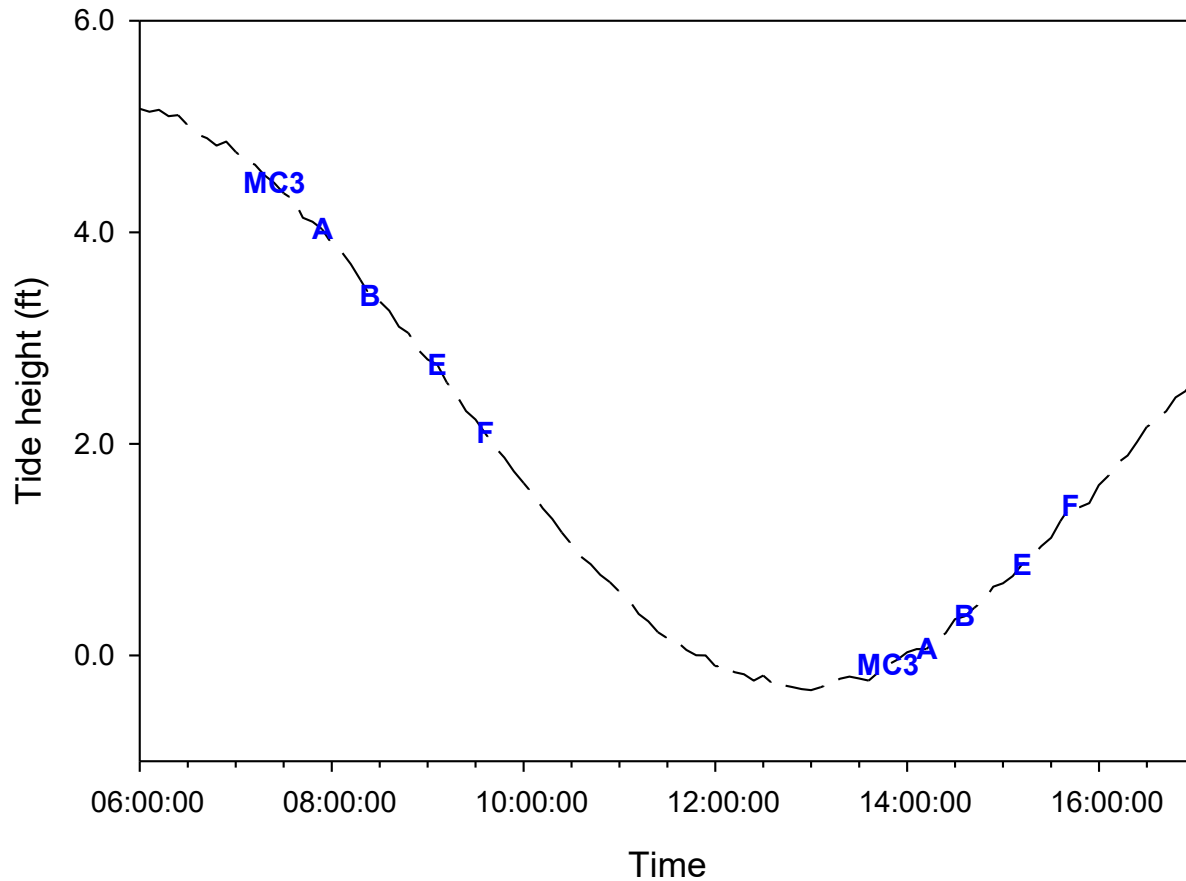


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Tables 2 and 3. In response to the Los Angeles Regional Board's request, field measurements were recorded for subsampled basin locations (inner, mid, and outer). For all stations, the measurements exhibited little variation among subsamples, indicating little spatial variability within each basin. The pH at the MdrH-MC3 station was elevated relative to the back basin station locations by approximately 0.10-0.15 pH units. Sample temperature generally increased by 0.5-2.0 °C between the morning and afternoon samples, with the lowest temperature observed for the MC3 morning sample (16.4°C). Dissolved copper concentrations for all stations exceeded the water quality criteria (3.1 µg/L) and ranged from 5.74 µg/L (MdrH-MC3) to 12.7 µg/L (MdrH-A). Basins E and F had similar dissolved copper concentrations and were in between the concentrations measured in Basins A and B. For the basin locations, these dissolved copper concentrations are similar to the wet weather WER 3 sampling event and are 1.5-2 times higher than in WERs 1 and 2 (summer dry weather samples). The lowest concentration was again observed at MdrH-MC3 (5.74 µg/L), with a similar value for MdrH-MC3 dup (6.62 µg/L). Although the lowest value for this event, the copper concentrations for MdrH-MC3 are 5.8-7 times higher than WER 3 and 1.5-3.5 times higher than WERs 1 and 2.

DOC concentrations were more variable with an overall range of 0.39 mg/L compared to the previous dry weather MdrRH samples (0.15 mg/L range). This variability of results was similar to the wet weather WER 3 event (1.24-1.58 mg/L, 0.34 mg/L range). The DOC concentrations for this event (0.71-1.10 mg/L) were similar to those observed for WER 1 (0.914-1.06 mg/L). The DOC results also showed a spatial trend with the main channel and basin A having lower DOC concentrations relative to basin B and the back basins (E and F). The DOC certified reference material was measured at 0.1 mg/L below the acceptable range, suggesting a possible low bias in the results.

In addition to the quantitative analysis of DOC, a subsample (10-20 mL) of the filtrate was taken for qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 4). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Based on the source and characterization of seven DOM isolates by Al-Reasi et al. (2012), they found SAC340 values for microbially-derived DOC in the range of 4-15, and terrestrially-derived DOC in the range of 28-40. These are not set thresholds for the two categories of DOC, but rather provide more context for data interpretation.

$$\text{SAC340} = 2303 (\text{Abs340}/\text{DOC})$$

Abs340 is the sample absorbance at 340 nm and DOC is the concentration in mg/L.

All the Harbor samples had relatively similar absorbance values that ranged from 0.0032 (MdrRH-MC3) to 0.0087 (MdrRH-E). Granite Canyon had the lowest absorbance (0.0001) value. The resulting SAC340 values range from 0.51 (Granite Canyon) to 21.68 (MdrRH-F). MdrRH-MC3 was the only station to fall within the microbially-derived DOC range (4-15), whereas the remaining stations fell in the unspecified range (15-28) between the microbial and terrestrial categories. This suggests there may be some DOC input from terrestrial sources, but microbially-sourced DOC seems to be the primary source. These SAC340 values are 1-16 times greater than previous dry weather values.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. Results and methods presented here were consistent with the QAPP, with one exception: 1) A thermometer was not included in the cooler of metals samples. However, these samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 3.9°C for the field and Day 0 toxicity samples and 0.8°C for the Day 2 toxicity samples indicating these samples were kept under acceptable conditions during transit. In addition, the field duplicate did not pass the precision criteria for total copper.

Table 2. Field measurements from the WER #4 sampling event on March 5, 2020.

Composite	Station	Basin Location	Sample Start Time	Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)
First	MdRH-MC3	--	0724	4.47	8.00	33.7	16.4	8.41
	MdRH-MC3 Dup	--	0724	4.47	8.00	33.6	16.6	8.55
	MdRH-A	Inner	0750	4.10	7.94	34.1	17.1	8.79
		Mid	0800	3.89	7.93	33.9	17.3	8.82
		Outer	0809	3.82	7.93	34.0	17.4	8.83
	MdRH-B	Inner	0824	3.40	7.93	34.0	17.3	8.83
		Mid	0835	3.26	7.94	33.9	17.8	9.01
		Outer	0845	3.05	7.92	33.9	18.0	8.79
	MdRH-E	Inner	0904	2.75	7.90	33.9	17.9	8.52
		Mid	0915	2.46	7.89	33.9	18.4	8.31
		Outer	0922	2.31	7.89	33.9	18.4	8.60
	MdRH-F	Inner	0934	2.10	7.89	34.0	18.2	8.62
		Mid	0943	1.97	7.89	34.0	18.0	8.58
		Outer	0952	1.74	7.88	33.9	18.0	8.21
	Second	MdRH-MC3	--	1347	-0.09	8.04	33.5	18.5
MdRH-MC3 Dup		--	1347	-0.09	8.05	33.6	18.5	8.96
MdRH-A		Inner	1408	0.06	8.00	33.7	18.2	8.56
		Mid	1415	0.14	7.97	34.0	18.5	8.66
		Outer	1422	0.21	7.96	34.0	18.6	8.78
MdRH-B		Inner	1435	0.37	7.98	33.6	18.6	8.81
		Mid	1445	0.52	8.00	33.8	18.3	9.03
		Outer	1453	0.65	7.99	33.8	18.5	8.93
MdRH-E		Inner	1510	0.86	7.97	33.7	18.7	8.82
		Mid	1519	0.94	7.95	33.7	18.7	8.93
		Outer	1527	1.11	7.95	33.6	18.7	9.01
MdRH-F		Inner	1539	1.41	7.93	33.6	18.6	8.96
		Mid	1545	1.40	7.91	33.8	18.7	8.76
		Outer	1552	1.44	7.92	33.8	18.6	8.67

DO-Dissolved oxygen

Dup-duplicate sample

Table 3. Chemistry results from the WER #4 sampling event on March 5, 2020.

Station	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)
MdRH-MC3	0.804	6.53	5.74	43.9	42.9
MdRH-MC3 Dup	0.707	16.1	6.62	44.6	42.0
MdRH-A	0.770	14.4	12.7	89.5	85.2
MdRH-B	0.976	11.7	10.3	78.5	75.0
MdRH-E	1.10	14.7	11.4	146	136
MdRH-F	0.903	12.4	11.3	82.7	77.3
QA Samples					
Tubing blank	< 0.055	2.07	0.553	0.464	0.428
Travel blank	--	0.0379	--	ND	--
Field blank	< 0.055	0.180	0.937	ND	ND
Filter blank 1	< 0.055	--	--	--	--
Filter blank 2	< 0.055	--	--	--	--
Filter blank 3	< 0.055	--	--	--	--
DOC matrix spike recovery	96%				
DOC CRM	0.84	below range (0.85-0.90)			

Diss.-Dissolved
Dup-duplicate sample

DOC-Dissolved organic carbon
ND-Not detected

Zn-Zinc

Cu-Copper

Table 4. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	0.804	0.0032	9.17
MdRH-MC3 dup	0.707	0.0052	16.94
MdRH-A	0.770	0.0056	16.75
MdRH-B	0.976	0.0065	15.34
MdRH-E	1.10	0.0087	18.21
MdRH-F	0.903	0.0085	21.68
Granite Canyon	0.454	0.0001	0.51

SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The test acceptability criteria for the mussel embryo development test require the control to have a mean survival of at least 50%, percent normal development of at least 90%, and a percent minimum significant difference (MSD) of less than 25%. This toxicity test met the first and third criteria with 100% survival in the Granite Canyon control and an MSD of 21%; however, the

percent normal development was 82% for the Granite Canyon control, which failed the test acceptability criteria.

The dissolved copper concentrations measured in the dose-response samples (Day 0 and Day 2) and the corresponding toxicity test results (percent normal mussel embryos and replicate standard deviation) are summarized in Table 5. In response to the Technical Advisory Committee, this was the first sampling event with copper measurements at the beginning and end of test duration. Overall, dissolved copper concentrations changed little during the test duration. The relative loss across all samples and doses was approximately 5%.

There were some important differences between WER Event 4 and previous WER Events. For example, there was increased variability in the toxicity results for this test. Cumulatively, 23% (13 out of 56) of the treatments in table 5 had replicate standard deviation values exceeding 10. Compared to previous WER events, 2-11% of treatments had replicate standard deviation values exceeding 10. Additionally, toxicity was observed in all un-spiked field samples from WER Event 4, which was not observed in any previous test. The dissolved copper concentrations for the un-spiked samples (5.31-11.8 µg/L) were greater than previous dry-weather events (1.71-7.91 µg/L), but similar to the basin samples from the wet weather WER Event 3 (9.17-11.5 µg/L). These higher dissolved copper concentrations, coupled with the lower DOC concentrations from WER Event 4 noted above, could result in the higher toxicity observed in the un-spiked samples.

An alternative hypothesis (or in addition to) explaining the increased toxicity observed in WER Event 4 could be the increased sensitivity of test organisms to copper compared to previous WER Events. This is supported by the reduced percent normal response in the Granite Canyon controls, as well as the increased variability in the toxicity test results.

The dose-response curves and EC50 values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 6). The calculated EC50 value for Granite Canyon (8.16 µg/L) was lower than the previous EC50 values, which ranged from 9.02-9.93 µg/L. This is further evidence of higher sensitivity in this batch of test organisms. The water effect ratios for the main channel and basin stations were calculated using the Granite Canyon water EC50 as the reference result (Table 6). EC50 values could not be calculated for MdrRH-A, -B, and -E as the toxicity in all concentrations was too high (< 50% normal). No WERs were calculated for these samples. For the remaining stations, the WERs ranged from 1.36 (MdrRH-MC3 dup) to 1.62 (MdrRH-F). The geometric mean of the three toxicity-based WERs was 1.45.

In addition to the toxicity-based WERs, the Biotic Ligand Model (BLM) was used to estimate EC50 and WER values for each sample (Table 6). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC50 results. Similar to the previous WER results, the measured EC50 values were higher than the BLM-predicted EC50 values. This was true for both the sample water as well as the reference water. The BLM-based WERs ranged from 1.56 (MdrRH-MC3 dup) to 2.42 (MdrRH-E), which was a larger range (0.86) than the toxicity-based WERs (0.26). Similar to the trend observed for DOC concentration, the back basin and basin B WERs were higher than the main channel and basin A WERs. This result is consistent with expectations based on the structure of

the BLM. The geometric mean of the BLM-WERs was 1.91 for all stations and 1.76 for the main channel and basin F results.

Quality assurance deviations for toxicity testing and chemical analyses for sampling Event 4 make these results suspect and eliminating them from the final WER determination is recommended. Toxicity test quality assurance deviations included low negative control survivorship across all replicates, ultimately failing to pass test acceptability criteria. Increased replicate variability was also observed, which is supporting evidence of sub-optimal test organism condition. To resolve this toxicity testing deviation, multiple organism suppliers will be used for future sampling events, and the best performing spawns will be used for testing. The increased copper concentrations observed for this winter dry-weather event (relative to previous summer dry-weather events) could be meaningful and important for toxicity management decisions. However, the increased copper concentrations in Event 4 MdrRH samples are confounded by dissolved copper concentrations observed in the equipment and field blanks for this event, low recovery of DOC from certified reference materials, and non-monotonic dissolved copper concentrations in sample MdrRH-B for Day 0. To resolve this chemistry deviation, cleaning protocols will be reviewed and updated, additional technician audit and training will occur, and continued blank testing will be incorporated into future sampling events.

Table 5. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
GC, 0 µg/L	0.238	4.79	82	4.5
GC, 4 µg/L	4.26	4.19	82	1.2
GC, 5.5 µg/L	5.10	5.87	64	33
GC, 7.0 µg/L	6.44	6.95	74	5.0
GC, 9.5 µg/L	8.77	8.51	27	15
GC, 13 µg/L	11.8	11.7	10	9.2
GC, 17 µg/L	15.8	16.5	4	3.4
GC, 23 µg/L	33.4	20.3	4	3.9
MdrRH-MC3, 0 µg/L	5.31	5.57	68	37
MdrRH-MC3, 4 µg/L	8.99	9.32	63	19
MdrRH-MC3, 5.5 µg/L	10.3	9.72	38	29
MdrRH-MC3, 7.0 µg/L	11.2	10.4	45	6.6
MdrRH-MC3, 9.5 µg/L	13.0	12.9	8	5.1
MdrRH-MC3, 13 µg/L	15.7	15.2	3	0.7
MdrRH-MC3, 17 µg/L	19.8	18.8	5	1.4
MdrRH-MC3, 23 µg/L	25.1	24.3	3	2.3
MdrRH-MC3 dup, 0 µg/L	6.41	6.92	67	34
MdrRH-MC3 dup, 4 µg/L	10.0	10.3	49	28
MdrRH-MC3 dup, 5.5 µg/L	10.8	10.7	56	14

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
MdRH-MC3 dup, 7.0 µg/L	10.9	11.9	24	15
MdRH-MC3 dup, 9.5 µg/L	14.2	12.7	7	2.2
MdRH-MC3 dup, 13 µg/L	16.6	16.4	5	2.0
MdRH-MC3 dup, 17 µg/L	20.1	19.6	4	2.0
MdRH-MC3 dup, 23 µg/L	24.4	22.8	3	2.2
MdRH-A, 0 µg/L	11.8	11.3	11	11
MdRH-A, 3 µg/L	14.3	13.7	5	2.1
MdRH-A, 4 µg/L	15.3	15.0	5	2.9
MdRH-A, 5.5 µg/L	16.5	16.1	4	2.8
MdRH-A, 7.0 µg/L	18.0	16.6	4	1.4
MdRH-A, 9.5 µg/L	22.9	19.0	7	8.3
MdRH-A, 13 µg/L	25.8	26.9	3	2.0
MdRH-A, 17 µg/L	27.7	25.8	6	9.9
MdRH-B, 0 µg/L	11.7	9.85	47	40
MdRH-B, 3 µg/L	22.9	12.2	21	7.1
MdRH-B, 4 µg/L	13.6	12.7	19	13
MdRH-B, 5.5 µg/L	15.1	13.9	9	8.4
MdRH-B, 7.0 µg/L	16.5	15.7	5	1.6
MdRH-B, 9.5 µg/L	18.1	17.1	3	2.4
MdRH-B, 13 µg/L	21.8	20.5	4	1.0
MdRH-B, 17 µg/L	25.4	22.9	3	2.2
MdRH-E, 0 µg/L	11.1	11.0	36	25
MdRH-E, 3 µg/L	13.6	12.7	19	7.8
MdRH-E, 4 µg/L	14.5	13.4	7	8.2
MdRH-E, 5.5 µg/L	15.8	14.8	4	2.2
MdRH-E, 7.0 µg/L	16.9	15.8	7	8.4
MdRH-E, 9.5 µg/L	20.3	17.5	4	1.4
MdRH-E, 13 µg/L	23.4	23.6	3	3.1
MdRH-E, 17 µg/L	26.6	29.8	6	9.5
MdRH-F, 0 µg/L	9.55	9.65	53	28
MdRH-F, 3 µg/L	12.6	12.1	35	16
MdRH-F, 4 µg/L	14.0	13.1	18	7.9
MdRH-F, 5.5 µg/L	14.4	13.6	5	1.5
MdRH-F, 7.0 µg/L	15.8	14.5	6	1.6
MdRH-F, 9.5 µg/L	21.7	16.2	7	6.0
MdRH-F, 13 µg/L	21.5	18.4	4	3.8
MdRH-F, 17 µg/L	24.6	26.1	3	2.7

Table 6. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results		Biotic Ligand Model Predictions	
	Copper EC50 (µg/L)	Calculated WER	Copper EC50 (µg/L)	Calculated WER
Granite Canyon	8.16		3.38	
MdRH-MC3	11.33	1.39	5.98	1.77
MdRH-MC3 duplicate	11.09	1.36	5.26	1.56
		1.37 (mean)		1.66 (mean)
MdRH-A ^a	< 11.8	--	5.73	1.70
MdRH-B ^a	< 11.7	--	7.25	2.14
MdRH-E ^a	< 11.1	--	8.18	2.42
MdRH-F	13.24	1.62	6.72	1.99
Geometric mean		1.45 ^b		1.91 (1.76 ^b)

^aEC50 values could not be calculated due to low toxicity in dose-response range.

^bGeometric mean calculated using only MdRH-MC3, -MC3 duplicate, and -F.

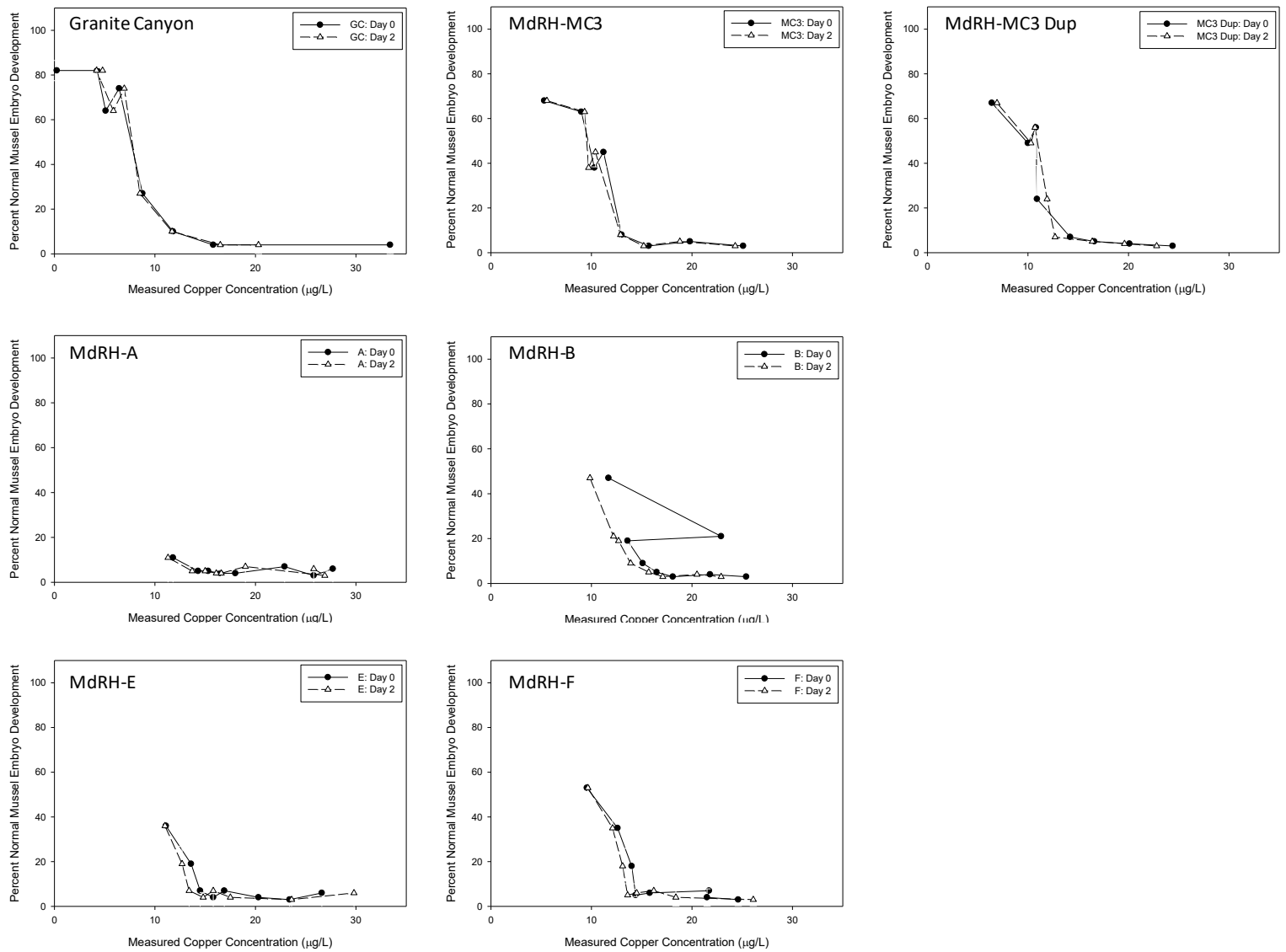


Figure 3. Dose response curves for reference water and field samples using dissolved copper concentrations from Day 0 (black circles) and Day 2 (open triangles).

References

Al-Reasi, H.A. and D.S. Smith. 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.

Tait, T.N., C.A. Cooper, J.C. McGeer, C.M. Wood, and D.S. Smith. 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.

USEPA. 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

APPENDIX C-5: WER SAMPLING EVENT 5 RESULTS SUMMARY: WET WEATHER

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Introduction

For the Marina del Rey Harbor (MdrH) Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six WER sampling events over the course of one year. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the fifth WER event, which covers the second wet weather sampling event.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MdrH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. Unlike the previous dry weather sampling events, this sampling was focused on rainfall and did not include composites based on the tidal cycle. The spatial composite samples were subsampled for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, water quality parameters were measured at each subsample location (inner, mid, and outer). Surface water salinity measurements were recorded at each subsample location to identify any potential salinity gradients due to the recent wet weather. A duplicate sample for all parameters was taken at station MdrH-MC3. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 µm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4°C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis at SCCWRP. The qualitative DOC samples were brought back to the laboratory and the absorbance (at 340 nm) was measured within 24 hours of sample filtration.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and kilned to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile. A new batch of supplies was ordered, and, as such, one of each item (syringe, filter, and centrifuge tube) was sent to Physis to analyze as a blank sample for metals. Physis rinsed each item with high purity laboratory water and analyzed the resulting samples. The syringe, centrifuge tube, and filter blank samples contained 0.05 µg/L, 0.11 µg/L, and 0.18 µg/L total copper, respectively. The copper concentrations in the syringe (0.05 µg/L) and centrifuge tube (0.11 µg/L) were elevated compared to the blank analyses from the first batch (no detectable copper for both). The field blank for this sampling event, which included the filter pre-rinse with DI water, contained no detectable copper, indicating no background contamination was present.

For the toxicity testing, field samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. Subsamples of each dose from day 0 and day 2 were filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1°C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, Windward v3.16.2.41) to calculate a predicted EC50 for *Mytilus galloprovincialis* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the BLM-based WER. These calculations provide a comparison between the model and laboratory-based results. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and

calculate EC50 values for each station. These calculations were performed using CETIS (v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon and MC3 samples (µg/L)	Basin Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

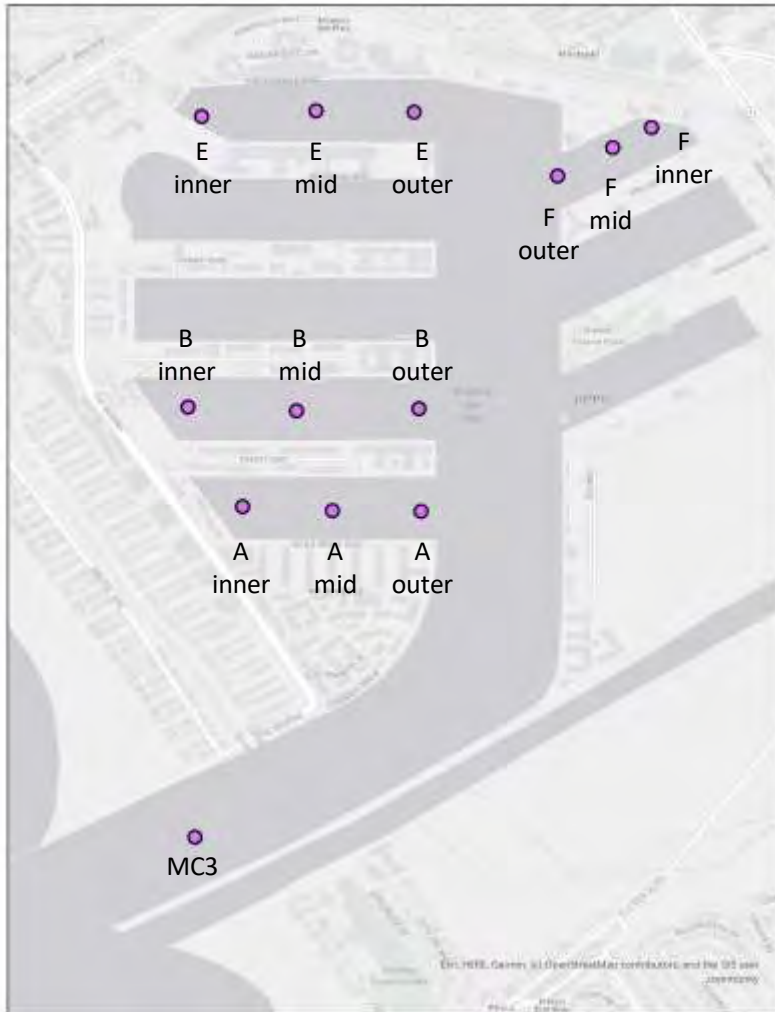


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Friday, March 13, 2020. This sampling event constituted the second wet weather sample collection for this project. The Workplan stipulates a wet weather event trigger of 0.5 inches of rain. For this event, a storm on March 12-13, 2020 produced approximately 1.99 inches of rain prior to sampling and after a dry antecedent period of two days. This storm continued to produce small amounts of rain through March 16, resulting in an additional 0.58 inches of rain over the three days following sampling. The previous rain event on March 10 produced 0.18 inches of rain, which was not enough to meet the wet weather trigger. Prior to March 10, 0.03 inches of rain was observed on January 21, 2020, and 0.44 inches of rain was observed from January 16 through 17. The rainfall data were obtained from the Los Angeles County Public Works precipitation map and rain gauge data website (<https://dpw.lacounty.gov/wrd/rainfall/#>). The Ballona Creek rain gauge provided the closest location to the Harbor.

Although tidal compositing was not performed during this sample event, the spatial composite samples taken at each location were related to tide height using the sample start time and the tide height based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 4 hours after the low tide (+0.55 ft) at +3.58 ft, and the final sample (MdrH-F) was taken approximately 6.5 hours after the low tide and 45 minutes after the high tide (+4.35 ft) at +4.23 ft. The overall tide change for the sampling window was +0.77 ft.

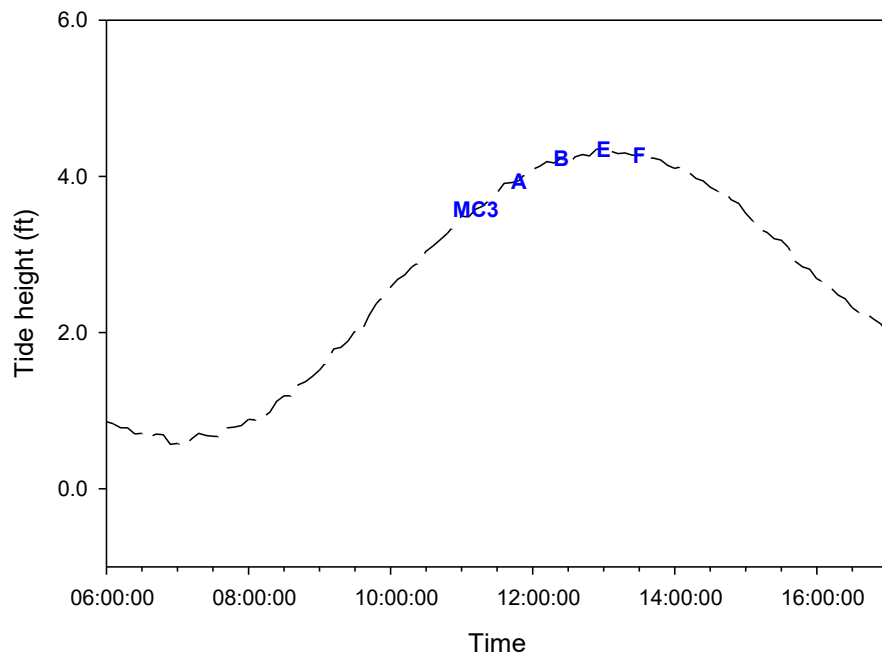


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Table 2. The pH and salinity measurements exhibited a gradient decreasing in value from the main channel to the front and back basins. The MdrH-MC3 station pH was elevated relative to the back basin station locations by approximately 0.18-0.27 pH units, which is similar to the difference observed in the previous wet weather sampling event (0.20-0.25 pH units). Salinity at the 1 m sampling depth ranged from 24.6 ppt (MdrH-F mid) to 33.2 ppt (MdrH-B inner). These values were reduced by approximately 1-9 ppt relative to previous dry weather sampling events. The salinity values for Basins E and F (24.6-30.4 ppt) were also reduced compared to the previous wet weather event, which had more consistent salinity values ranging from 30.4 to 32.2 ppt.

Additional salinity measurements were taken in the surface water at each subsample location (Table 3). The probes were placed into the water over the side of the boat until deep enough to submerge the probe and obtain a reading. A spatial gradient was observed with MdrH-MC3 (17.8 ppt) and Basin E (16.8-23.0 ppt) having the lowest surface salinity. Basins A, B, and F had

similar salinity values (approximately 25 ppt). All stations had reduced salinity in the surface water compared to the sample depth 1m below with one exception (MdrRH-F mid).

Dissolved copper concentrations in all basin stations exceeded the water quality criteria (3.1 µg/L) and ranged from 8.18 µg/L (MdrRH-F) to 8.97 µg/L (MdrRH-E) (Table 2). All basin stations had similar dissolved copper concentrations with no spatial pattern. This wet weather event typically had greater dissolved copper concentrations in the basins than the previous dry weather WER events (WER 1 basins, 7.10-9.55 µg/L; WER 2 basins, 5.27-6.54 µg/L). However, this wet weather event was lower than the previous wet weather event (WER 3 basins, 10.2-12.9 µg/L). The lowest concentration during this sampling event was below the water quality criteria and was observed at MdrRH-MC3 dup (1.90 µg/L), with a similar value for MdrRH-MC3 (2.08 µg/L). The dissolved copper concentrations at the MdrRH-MC3 station were higher than the first wet weather event (WER 3, 0.821-1.13 µg/L) and the summer, dry weather spring tide event (WER 2, 1.78 µg/L), but lower than the summer, dry weather neap tide event (WER 1, 3.64 µg/L).

Wet weather DOC concentrations ranged from 1.06 mg/L (front basins A and B) to 1.42 mg/L (MdrRH-E) (Table 2). These values were lower than the previous wet weather event (1.24-1.58 mg/L) and were intermediate relative to the previous dry weather events. The range in DOC concentrations for this wet weather event (0.36 mg/L) was similar to the previous wet weather event (0.34 mg/L range). The results also showed a spatial trend with the main channel and front basins (A and B) having lower DOC concentrations (1.06-1.19 mg/L) relative to the back basins (E and F, 1.32-1.42 mg/L). The concentration of DOC in the Granite Canyon reference water was below the detection limit (< 0.055 mg/L) and could not be quantified. Granite Canyon DOC concentrations ranged from 0.45-1.00 mg/L in the previous wet- and dry-weather sampling events, with an average of 0.77 mg/L. The DOC certified reference material was measured within the acceptable range.

In addition to the quantitative analysis of DOC, a subsample (5-10 mL) of the filtrate was taken for qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 4). Typically, more aromatic, terrestrially derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Based on the source and characterization of seven DOM isolates by Al-Reasi et al. (2012), they found SAC340 values for microbially-derived DOC in the range of 4-15, and terrestrially derived DOC in the range of 28-40. These are not set thresholds for the two categories of DOC, but rather provide more context for data interpretation.

$$\text{SAC340} = 2303 (\text{Abs340}/\text{DOC})$$

Abs340 is the sample absorbance at 340 nm and DOC is the concentration in mg/L. All the Harbor samples had relatively similar absorbance values except for MdrRH-E and -F, which had the highest absorbance values (0.0101 and 0.0103). This may be due to more terrestrial runoff following the rain event. However, due to the higher DOC concentrations in the back basins, the resulting SAC340 values were similar for all Harbor samples and ranged from 12.34 (MdrRH-MC3) to 17.87 (MdrRH-F). Two of the samples have SAC340 values around the high end of the reported microbially-derived DOC range (MdrRH-MC3 and -B), with the other samples in the unspecified range (15-28) between the microbial and terrestrial categories. The overall increase

in SAC340 values in wet weather could indicate a shift to more terrestrially derived DOC relative to the dry sampling event results.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. Results and methods presented here were consistent with the QAPP, with one exception: 1) A thermometer was not included in the cooler of metals samples. However, these samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 3.9 °C indicating these samples were kept under acceptable conditions during transit.

Table 2. Data collected from the WER #5 sampling event on March 13, 2020.

Station	Basin Location	Sample Start Time	Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)
MdRH-MC3	--	1110	3.58	8.07	32.0	15.8	8.94	1.19	3.66	2.08	23.3	20.6
MdRH-MC3 Dup	--	1110	3.58	8.04	32.2	15.9	8.38	1.06	3.49	1.90	23.0	19.4
MdRH-A	Inner	1140	3.92	7.96	32.5	16.7	8.48	1.06	9.70	8.61	60.8	63.4
	Mid	1150	3.94	7.93	32.9	16.7	8.33					
	Outer	1158	4.09	7.92	32.8	16.7	7.80					
MdRH-B	Inner	1211	4.19	7.89	33.2	17.0	7.60	1.15	10.8	8.91	67.3	64.5
	Mid	1222	4.23	7.90	32.3	16.8	6.77					
	Outer	1231	4.15	7.91	30.2	16.5	6.88					
MdRH-E	Inner	1248	4.26	7.84	30.4	17.2	9.69	1.42	12.0	8.97	89.6	83.7
	Mid	1259	4.35	7.86	27.6	17.5	8.06					
	Outer	1307	4.32	7.83	29.1	17.6	8.30					
MdRH-F	Inner	1320	4.30	7.80	31.4	18.0	7.22	1.32	11.1	8.18	71.2	66.0
	Mid	1332	4.27	7.85	24.6	18.0	6.77					
	Outer	1339	4.23	7.82	29.2	18.5	6.30					
QA Samples												
Tubing blank								< 0.055	ND	ND	0.3	ND
Travel blank								--	ND	--	ND	--
Field blank								< 0.055	ND	ND	ND	ND
Filter blank 1								< 0.055	--	--	--	--
Filter blank 2								< 0.055	--	--	--	--
Filter blank 3								< 0.055	--	--	--	--
DOC matrix spike recovery								102%				
DOC CRM								0.87	within range (0.85-0.90)			

Diss.-Dissolved
ND-Not detected

DO-Dissolved oxygen

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

Dup-duplicate sample

Table 3. Surface water salinity field measurements.

Station	Salinity (ppt)			
	Inner	Mid	Outer	Average
MdRH-MC3	--	17.8	--	17.8
MdRH-A	28.4	25.1	25.6	26.4
MdRH-B	24.3	25.3	24.7	24.8
MdRH-E	16.8	20.7	23.0	20.2
MdRH-F	25.8	26.4	23.5	25.2

Table 4. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	1.19	0.0064	12.34
MdRH-MC3 dup	1.06	0.0069	15.11
MdRH-A	1.06	0.0072	15.65
MdRH-B	1.15	0.0065	13.13
MdRH-E	1.42	0.0101	16.38
MdRH-F	1.32	0.0103	17.87
Granite Canyon	< 0.055	0.0003	--

SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The test acceptability criteria for the mussel embryo development test require a control mean survival of at least 50%, percent normal development of at least 90%, and a percent minimum significant difference (PMSD) of less than 25%. This toxicity test met the first and third criteria with 100% survival in the Granite Canyon control and an PMSD of 14%; however, the percent normal development was 79% for the Granite Canyon control, which failed the test acceptability criteria. One of the five replicates was determined to be a statistical outlier and visual observations in the data sheets noted this replicate sample had more debris compared to the other replicates, indicating a likely anomaly due to potential contamination in that particular test vial. If the statistical outlier is removed, the control passes the test acceptability criteria with an average of 93% normal development and a standard deviation of 0.7%. The SCCWRP laboratory seawater, while not the official control, exhibited an average of 94% normal development and a standard deviation of 1.3% in the five replicates. These results were presented to the TAC and the decision was made to exclude the one control replicate.

The dissolved copper concentrations measured in the dose-response samples (Day 0 and Day 2) and the corresponding toxicity test results (percent normal mussel embryos and replicate standard deviation) are summarized in Table 5. Overall, dissolved copper concentrations

changed little during the test duration. The average percent difference across all samples and doses was approximately 8%. Similar to previous WER events, all un-spiked MdrRH samples had greater than 90% normal development, indicating no ambient toxicity, even with copper concentrations in the basins above the current water quality criterion (3.1 µg/L). However, there was increased variability in the toxicity results for this test. Cumulatively, 32% (18 out of 56) of the treatments in table 5 had replicate standard deviation values exceeding 10. Compared to previous WER events, 2-11% of treatments had replicate standard deviation values exceeding 10.

The dose-response curves and EC50 values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 6). The calculated EC50 value for Granite Canyon (6.89 µg/L) was lower than the previous EC50 values, which ranged from 9.02-9.93 µg/L. This could indicate higher sensitivity in this batch of test organisms. The water effect ratios for the main channel and basin stations were calculated using the Granite Canyon water EC50 as the reference result (Table 6). The WERs ranged from 1.57 (MdrRH-MC3 dup) to 2.04 (MdrRH-F). These values increased from the front to the back basins, indicating a spatial trend. The geometric mean of the toxicity based WERs was 1.78. The individual WERs and geometric mean are greater than those from previous sampling events. The previous wet weather event (WER 3) had a value (geometric mean = 1.57) between Event 5 and the dry events sampled in Events 1 and 2 (geometric means = 1.31 and 1.39).

In addition to the toxicity based WERs, the Biotic Ligand Model (BLM) was used to estimate EC50 and WER values for each sample (Table 6). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC50 results. The day 0 water quality measurements were taken prior to addition of the test organisms, and the day 2 water quality measurements were taken upon test breakdown and most accurately reflect the test conditions. The DOC concentration in the Granite Canyon sample was below detection limit. As such, the detection limit of 0.055 mg/L was used for the BLM-based EC50 calculation for Granite Canyon. This DOC concentration is approximately one order of magnitude lower than previous DOC measurements in Granite Canyon reference water. Similar to previous WER results, the measured EC50 values were higher than the BLM-predicted EC50 values. This was true for both the sample water as well as the reference water. The BLM-based WERs ranged from 17.9 (MdrRH-MC3 dup and -A) to 22.1 (MdrRH-F), with higher WERs in the back basins relative to the front basins and main channel. This spatial trend is consistent with the DOC concentrations and the laboratory-based WER results. The BLM-based WERs are higher than previous events by one order of magnitude, likely due to the low DOC concentration used for the Granite Canyon sample. Overall, the geometric mean of the wet weather BLM-WERs was 20.1.

Table 5. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
SCCWRP lab seawater	--	--	94	1.3
GC, 0 µg/L	0.120	0.623	79 ^a (93 ^b)	32 ^a (0.7 ^b)
GC, 4 µg/L	3.35	3.92	90	3.7
GC, 5.5 µg/L	4.38	4.83	90	4.0
GC, 7.0 µg/L	6.18	6.56	62	22.4
GC, 9.5 µg/L	8.46	8.88	17	7.2
GC, 13 µg/L	10.8	11.8	5	6.2
GC, 17 µg/L	14.7	15.4	8	6.8
GC, 23 µg/L	20.0	20.9	3	6.6
MdRH-MC3, 0 µg/L	1.94	2.63	86	21.3
MdRH-MC3, 4 µg/L	5.11	5.17	95	1.7
MdRH-MC3, 5.5 µg/L	6.02	6.31	95	1.7
MdRH-MC3, 7.0 µg/L	6.98	7.35	94	2.5
MdRH-MC3, 9.5 µg/L	8.90	9.26	86	9.3
MdRH-MC3, 13 µg/L	11.5	11.8	36	2.8
MdRH-MC3, 17 µg/L	14.7	15.4	18	15.6
MdRH-MC3, 23 µg/L	19.2	19.0	8	9.8
MdRH-MC3 dup, 0 µg/L	1.70	2.33	94	1.8
MdRH-MC3 dup, 4 µg/L	4.95	5.15	81	34.9
MdRH-MC3 dup, 5.5 µg/L	5.80	6.26	78	40.4
MdRH-MC3 dup, 7.0 µg/L	6.94	7.23	95	1.6
MdRH-MC3 dup, 9.5 µg/L	8.69	9.42	90	7.2
MdRH-MC3 dup, 13 µg/L	10.7	12.5	49	32.2
MdRH-MC3 dup, 17 µg/L	13.0	15.4	8	7.0
MdRH-MC3 dup, 23 µg/L	17.9	18.6	1	0.9
MdRH-A, 0 µg/L	7.27	8.72	93	2.4
MdRH-A, 3 µg/L	9.54	8.83	73	35.8
MdRH-A, 4 µg/L	10.2	10.6	70	15.2
MdRH-A, 5.5 µg/L	11.4	11.9	56	31.5
MdRH-A, 7.0 µg/L	13	12.9	26	15.9
MdRH-A, 9.5 µg/L	14.9	15.5	12	9.1
MdRH-A, 13 µg/L	17.9	18.5	3	1.8
MdRH-A, 17 µg/L	21.2	22.2	9	10.3
MdRH-B, 0 µg/L	7.99	8.14	92	4.5
MdRH-B, 3 µg/L	10.6	10.8	76	13.4
MdRH-B, 4 µg/L	13.0	12.9	29	12.2
MdRH-B, 5.5 µg/L	14.1	14.2	13	4.2

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
MdRH-B, 7.0 µg/L	15.7	15.1	4	2.8
MdRH-B, 9.5 µg/L	17.7	18.1	8	9.4
MdRH-B, 13 µg/L	20.5	20.8	4	6.5
MdRH-B, 17 µg/L	23.8	24.3	4	7.5
MdRH-E, 0 µg/L	8.54	8.65	92	2.2
MdRH-E, 3 µg/L	10.5	10.5	84	4.2
MdRH-E, 4 µg/L	11.3	11.4	57	33.8
MdRH-E, 5.5 µg/L	12.3	12.7	68	19.6
MdRH-E, 7.0 µg/L	13.9	12.9	40	27.1
MdRH-E, 9.5 µg/L	16.2	15.5	7	3.7
MdRH-E, 13 µg/L	18.6	17.3	15	11.4
MdRH-E, 17 µg/L	22.1	21.3	12	9.6
MdRH-F, 0 µg/L	7.67	7.86	92	4.1
MdRH-F, 3 µg/L	10.2	10.2	91	4.8
MdRH-F, 4 µg/L	11.0	10.5	89	5.2
MdRH-F, 5.5 µg/L	12.2	11.7	79	7.1
MdRH-F, 7.0 µg/L	13.4	13.0	59	9.3
MdRH-F, 9.5 µg/L	15.0	14.9	18	12.0
MdRH-F, 13 µg/L	18.3	17.3	8	9.3
MdRH-F, 17 µg/L	22.1	20.7	7	8.2

^aN=5

^bN=4

Table 6. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results			Biotic Ligand Model Predictions		
	Copper EC50 (µg/L)	Calculated WER		Copper EC50 (µg/L)	Calculated WER	
Granite Canyon	6.89 ^a			0.44 ^b		
MdRH-MC3	11.49	1.67	1.62 (mean)	8.75	20.1	19.0 (mean)
MdRH-MC3 duplicate	10.82	1.57		7.79	17.9	
MdRH-A	11.86	1.72		7.82	17.9	
MdRH-B	12.09	1.76		8.42	19.9	
MdRH-E	13.39	1.94		10.40	23.9	
MdRH-F	14.02	2.04		9.63	22.1	
Geometric mean		1.78			20.1	

^aEC50 calculated using reduced sample size (n=4).

^bThe BLM was run using the DOC detection limit for the Granite Canyon sample.

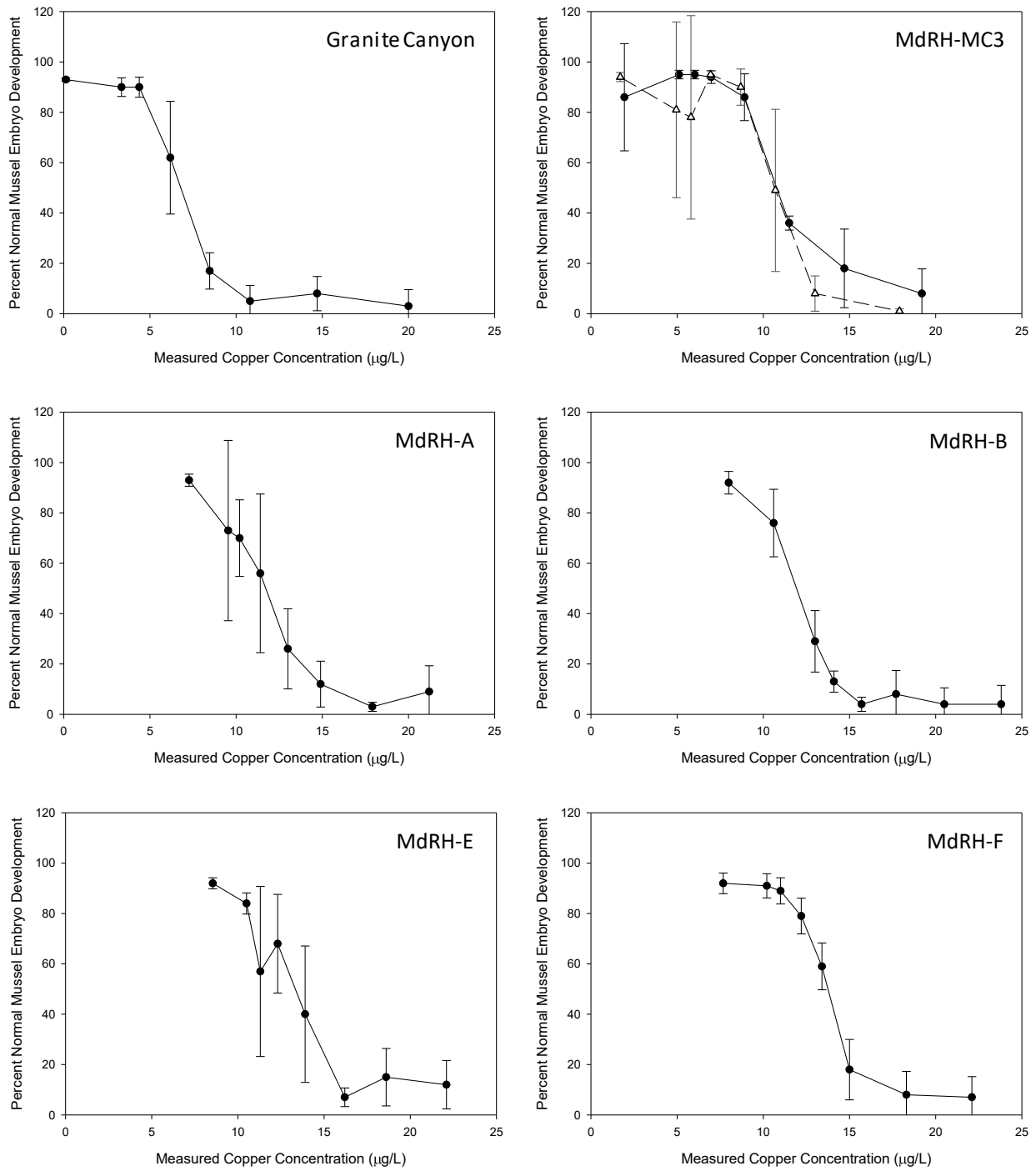


Figure 3. Dose response curves for reference water and field samples. MdRH-MC3 (circles) and MdRH-MC3 dup (triangles) are plotted together.

References

Al-Reasi, H.A. and D.S. Smith. 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.

Tait, T.N., C.A. Cooper, J.C. McGeer, C.M. Wood, and D.S. Smith. 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.

USEPA. 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

APPENDIX C-6: WER SAMPLING EVENT 6 RESULTS SUMMARY: WINTER DRY WEATHER, NEAP TIDE

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February 2, 2021

Introduction

For the Marina del Rey Harbor Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six successful WER sampling events. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the sixth WER event, which covers the winter dry weather, neap tide sampling event.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MdrRH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. This sampling was repeated once more such that a spatially representative sample was taken during both flood and ebb tide. Once all sampling was complete, these two samples were composited to create one final sample per station. This sample was subsampled for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, water quality parameters were measured at each subsample location (inner, mid, and outer). A duplicate sample for all parameters was taken at station MdrRH-A. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 µm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4°C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis at SCCWRP. The qualitative DOC samples were brought back to the laboratory and the absorbance (at 340 nm) was measured within 24 hours of sample filtration.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and kilned to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile. The background copper and zinc concentrations in the tubing, travel, and field blanks were below the detection limits (0.005 µg Cu/L and 0.0025 µg Zn/L).

For the toxicity testing, field samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. Subsamples of each dose from day 0 and day 2 were filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1°C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, Windward v3.16.2.41) to calculate a predicted EC50 for *Mytilus galloprovincialis* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the BLM-based WER. These calculations provide a comparison between the model and laboratory-based results. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and calculate EC50 values for each station. These calculations were performed using CETIS (v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon and MC3 samples (µg/L)	Basin Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

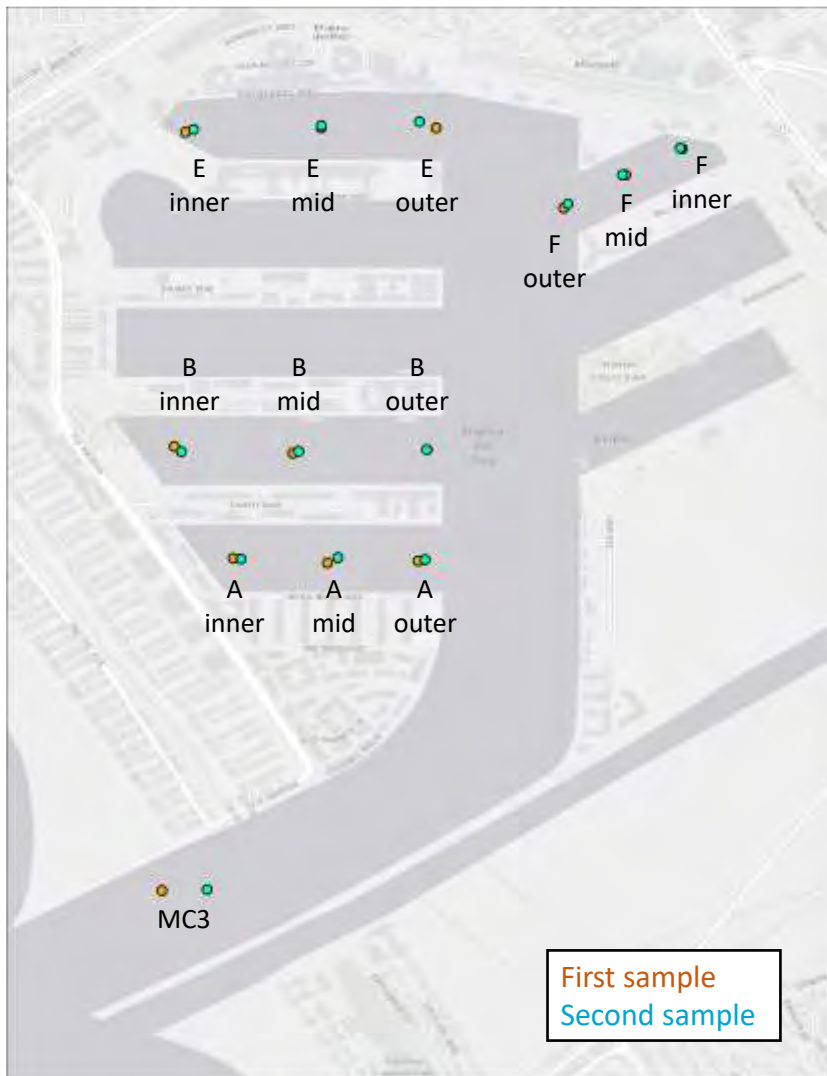


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Tuesday, November 10, 2020. This sampling event constituted the winter dry weather, neap tide sample collection. Sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 1.5 hours after the high tide (+4.54 ft) at +3.99 ft, and the final sample (MdrH-F) was taken approximately 3 hours after the low tide (1.78 ft) at +3.39 ft. The overall tide change for the sampling window was +2.21 ft.

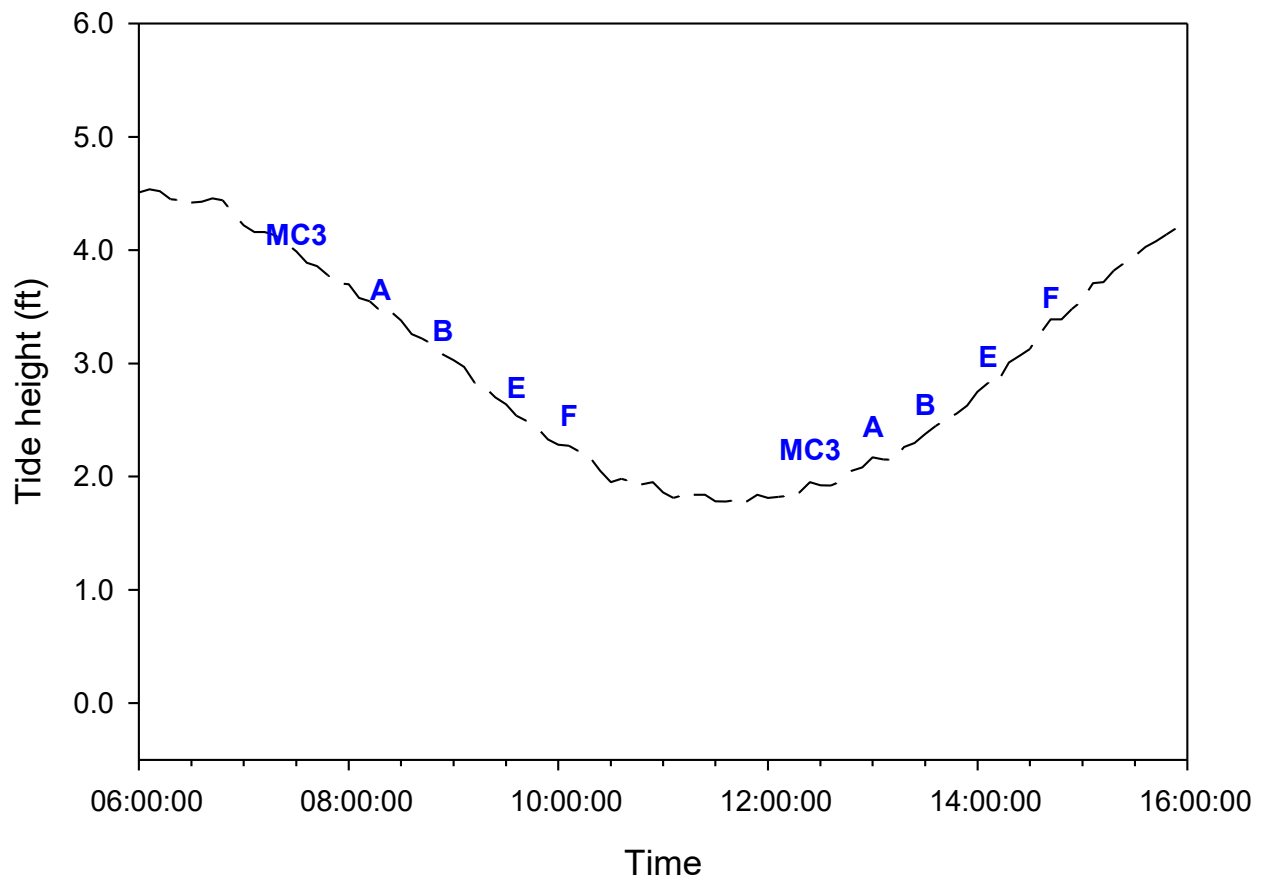


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Tables 2 and 3. In response to the Los Angeles Regional Board's request, field measurements were recorded for subsampled basin locations (inner, mid, and outer). For all stations, the measurements exhibited little variation among subsamples, indicating little spatial variability

within each basin. The pH values ranged from 7.47 to 7.72, with no clear spatial trends. Sample temperature increased by approximately 0.5-2.0 °C after the first two stations, with the lowest temperature observed for the MC3 morning sample (14.3°C).

Dissolved copper concentrations for all stations exceeded the water quality criteria (3.1 µg/L) and ranged from 3.45 µg/L (MdrRH-MC3) to 10.5 µg/L (MdrRH-E). For the basin stations, Basin B had the lowest dissolved copper concentration (7.18 µg/L). For the basin locations, these dissolved copper concentrations were similar to the WER 1 summer dry weather (neap tide) and the WER 5 wet weather sampling events. They were 1.2-2 times higher than in the WER 2 (summer dry weather, spring tide) sampling event, and 1-1.8 times lower than in the WER 3 (wet weather) sampling event. The copper concentration for MdrRH-MC3 (3.45 µg/L) was similar to the value from the WER 1 (summer dry weather, neap tide) sampling event (3.64 µg/L), but approximately 1.6-4 times higher than WERs 2, 3, and 5.

The variability in DOC concentration was similar to the two wet weather events (WERs 3 and 5) with a range of 0.43 mg/L, which is higher compared to the summer dry weather WER samples (0.15-0.2 mg/L range). The DOC concentration range for this event (1.16-1.59 mg/L) was also similar to the range observed for the two wet weather events (WER 3 = 1.24-1.58 mg/L, and WER 5 = 1.06-1.42 mg/L). The DOC results also showed a spatial trend with the main channel and back basins (E and F) having lower DOC concentrations relative to the front basins (A and B).

In addition to the quantitative analysis of DOC, a subsample (10-20 mL) of the filtrate was taken for qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 4). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Based on the source and characterization of seven DOM isolates by Al-Reasi et al. (2012), they found SAC340 values for microbially-derived DOC in the range of 4-15, and terrestrially-derived DOC in the range of 28-40. These are not set thresholds for the two categories of DOC, but rather provide more context for data interpretation.

$$\text{SAC340} = 2303 (\text{Abs340}/\text{DOC})$$

Abs340 is the sample absorbance at 340 nm and DOC is the concentration in mg/L.

All the Harbor samples had relatively similar absorbance values that ranged from 0.0031 (MdrRH-MC3) to 0.0047 (MdrRH-E). Granite Canyon had the lowest absorbance (0.0016) value. The resulting SAC340 values ranged from 3.84 (Granite Canyon) to 8.78 (MdrRH-E). All the stations fell within the microbially-derived DOC range (4-15), suggesting microbially-sourced DOC is the primary source. This is consistent with the expectations for dry weather sampling and are similar to the SAC340 values reported for the previous dry weather sampling events.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. Total and dissolved copper data passed all data quality objectives. Results and methods presented here were consistent with the QAPP, with two exceptions: 1) DOC data should be qualified. Although laboratory blanks, lab duplicates, and field duplicates all met data quality objectives for

precision, accuracy assessments using certified reference materials and matrix spikes did not. The DOC certified reference material was measured at 0.06 mg/L above the acceptable range (0.85-0.90 mg/L), suggesting a high bias in the results. Matrix spike of the lab blank was 55% of the spike value, and matrix spike of the field sample was 436% of spike the spike value. After following the QAPP actions associated with this deviation, including re-analysis of the spiked samples, the analysts deduced that improper spiking occurred. Unfortunately, there was no additional sample water for creating new spiked samples, but blank spikes in the runs prior to and after this batch met data quality objectives; 2) A thermometer was not included in the cooler of metals samples. However, these samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 1.9 °C for the field and Day 0 toxicity samples and 3.9°C for the Day 2 toxicity samples indicating these samples were kept under acceptable conditions during transit.

Table 2. Field measurements from the WER #6 sampling event on November 10, 2020.

Composite	Station	Basin Location	Sample Start Time	Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	
First	MdRH-MC3	--	0729	3.99	7.72	34.4	14.3	6.65	
	MdRH-A	Inner	0801	3.70	7.68	35.0	15.7	6.63	
		Mid	0815	3.47	7.64	34.8	16.2	6.46	
		Outer	0827	3.38	7.60	34.9	16.5	6.65	
	MdRH-A Dup	Inner	0801	3.70	7.65	34.8	15.6	6.75	
		Mid	0815	3.47	7.62	34.8	16.3	6.75	
		Outer	0827	3.38	7.60	34.9	16.5	6.84	
	MdRH-B	Inner	0843	3.22	7.58	35.1	16.5	6.03	
		Mid	0854	3.08	7.56	34.9	16.8	6.49	
		Outer	0905	2.97	7.55	34.7	16.9	6.68	
	MdRH-E	Inner	0923	2.70	7.49	35.3	17.3	6.04	
		Mid	0933	2.54	7.48	34.7	17.6	5.97	
		Outer	0942	2.49	7.51	35.0	17.7	6.13	
	MdRH-F	Inner	0955	2.33	7.53	34.4	17.2	6.29	
		Mid	1002	2.28	7.51	35.1	17.3	6.27	
		Outer	1010	2.22	7.52	35.2	17.2	6.31	
	Second	MdRH-MC3	--	1224	1.95	7.60	35.0	16.6	7.16
		MdRH-A	Inner	1246	2.05	7.60	35.0	17.0	6.85
			Mid	1257	2.08	7.58	35.1	16.9	6.65
			Outer	1305	2.15	7.63	34.1	16.8	6.68
		MdRH-A Dup	Inner	1246	2.05	7.60	35.0	16.6	6.99
Mid			1257	2.08	7.59	35.1	16.7	6.70	
Outer			1305	2.15	7.61	35.3	16.9	6.79	
MdRH-B	Inner	1322	2.30	7.55	35.0	16.9	6.52		

Composite	Station	Basin Location	Sample Start Time	Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)
		Mid	1331	2.38	7.55	35.2	17.1	6.49
		Outer	1340	2.51	7.56	35.1	17.0	6.66
	MdRH-E	Inner	1358	2.75	7.48	35.0	17.3	6.11
		Mid	1407	2.83	7.47	35.2	17.6	6.20
		Outer	1417	3.01	7.49	35.2	17.5	6.16
	MdRH-F	Inner	1428	3.13	7.52	34.6	17.1	6.51
		Mid	1439	3.39	7.52	35.2	17.1	6.41
		Outer	1447	3.39	7.55	34.9	17.0	6.46

DO-Dissolved oxygen

Dup-duplicate sample

Table 3. Chemistry results from the WER #6 sampling event on November 10, 2020.

Station	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)
MdRH-MC3	1.19	4.10	3.45	26.9	26.5
MdRH-A	1.59	8.76	8.34	51.3	50.7
MdRH-A Dup	1.39	9.12	8.26	51.2	51.0
MdRH-B	1.41	8.43	7.18	51.4	50.0
MdRH-E	1.22	12.6	10.5	98.4	102
MdRH-F	1.16	9.06	7.63	60.7	59.8
QA Samples					
Tubing blank	< 0.055	ND	ND	ND	ND
Travel blank	--	ND	--	ND	--
Field blank	< 0.055	ND	ND	ND	ND
Filter blank 1	< 0.055	--	--	--	--
Filter blank 2	< 0.055	--	--	--	--
Filter blank 3	< 0.055	--	--	--	--
DOC CRM	0.96	above range (0.85-0.90)			

Diss.-Dissolved

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

Dup-duplicate sample

ND-Not detected

Table 4. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	1.19	0.0031	6.00
MdRH-A	1.59	0.0041	5.98
MdRH-A Dup	1.39	0.0036	5.89
MdRH-B	1.41	0.0040	6.60
MdRH-E	1.22	0.0047	8.78
MdRH-F	1.16	0.0035	6.99
Granite Canyon	0.97	0.0016	3.84

SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The test acceptability criteria for the mussel embryo development test require the control to have a mean survival of at least 50%, percent normal development of at least 90%, and a percent minimum significant difference (MSD) of less than 25%. This toxicity test met all three criteria with 100% survival in the Granite Canyon reference water, an average of 93% normal development, and an MSD of 10%.

The dissolved copper concentrations measured in the dose-response samples (Day 0 and Day 2) and the corresponding toxicity test results (percent normal mussel embryos and replicate standard deviation) are summarized in Table 5. Overall, dissolved copper concentrations changed little during the test duration. The average percent difference across all samples and doses was approximately 6%. Replicate variability was in the same range (2-11%) as observed in WERs 1-3, with 7% (4 out of 56) of the treatments having replicate standard deviation values exceeding 10. This variability is less than was observed in WER 5 (32%). For the higher spiked MdRH-E samples (5.5 µg/L and above), only two replicates were counted due to the high toxicity response. The percent normal values were less than 10% at lesser copper concentrations, minimizing the need for toxicity data at higher copper concentrations.

Toxicity was observed in all un-spiked basin samples, which was not observed in the prior WER events. The dissolved copper concentrations for the Day 0 un-spiked basin samples (6.87-10.1 µg/L) were greater than previous dry-weather events (4.72-7.91 µg/L), but similar to the basin samples from the wet weather WER Event 3 (9.17-11.5 µg/L). DOC concentrations for the basin samples from this event (1.16-1.59 mg/L) were greater than WER 1 (summer dry, neap tide, 0.91-1.06 mg/L), but similar to the WER 2 (summer dry, spring tide, 1.4-1.6 mg/L) and WERs 3 and 5 (wet weather, 1.06-1.58 mg/L) events.

Test animal sensitivity was similar to previous WER events, suggesting that animal health was not the reason for the observed toxicity from the inner basins. The average percent normal response in the un-spiked Granite Canyon reference water in this event (93%) was similar to the control response observed in previous tests (91-96%). The calculated dissolved copper EC₅₀ value for the Granite Canyon reference water (10.07 µg/L) was slightly elevated relative to

previous tests (6.89-9.93 $\mu\text{g/L}$), which indicates comparable to less sensitive test organisms compared to the other WER events.

The dose-response curves and EC50 values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 6). The water effect ratios for the main channel and basin stations were calculated using the Granite Canyon reference water EC50 as the reference result (Table 6). An EC50 value and WER could not be calculated for MdrH-E as the toxicity in all concentrations was too high (< 50% normal development). For the remaining stations, the WERs ranged from 0.89 (MdrH-A Dup) to 1.09 (MdrH-F). The geometric mean of the three toxicity-based WERs was 0.99. The individual WERs and geometric mean are lower than those from all previous sampling events. The summer dry weather events (WERs 1 and 2) had geometric means ranging from 1.31 to 1.39. The wet weather events (WERs 3 and 5) had the highest geometric mean WERs ranging from 1.57 to 1.78.

In addition to the toxicity-based WERs, the Biotic Ligand Model (BLM) was used to estimate EC50 and WER values for each sample (Table 6). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC50 results. The day 0 water quality measurements were taken prior to addition of the test organisms, and the day 2 water quality measurements were taken upon test breakdown and most accurately reflect the test conditions. The Granite Canyon reference water had a greater measured EC50 value compared to the modeled value, a pattern which is consistent with previous events. However, unlike previous observations, the measured EC50 values for the MdrH samples were in the same range as the BLM-predicted EC50 values. The BLM-based WERs ranged from 1.19 (MdrH-F) to 1.64 (MdrH-A), which was a larger range (0.45) than the toxicity-based WERs (0.2). Similar to the trend observed for DOC concentration, the front basin WERs were greater than the main channel and back basin WERs. The geometric mean of the BLM-based WERs was 1.36.

Table 5. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
SCCWRP lab seawater	--	--	91	2.3
GC, 0 µg/L	0.196	0.837	93	0.7
GC, 4 µg/L	3.50	3.59	89	2.7
GC, 5.5 µg/L	4.99	5.52	87	3.9
GC, 7.0 µg/L	6.30	6.82	87	1.6
GC, 9.5 µg/L	8.48	9.42	68	12.6
GC, 13 µg/L	12.1	11.4	26	12.1
GC, 17 µg/L	15.3	15.8	6	2.3
GC, 23 µg/L	20.7	20.9	4	2.5
MdRH-MC3, 0 µg/L	3.36	4.19	91	1.6
MdRH-MC3, 4 µg/L	6.73	7.46	81	3.3
MdRH-MC3, 5.5 µg/L	8.07	8.03	75	5.2
MdRH-MC3, 7.0 µg/L	9.05	8.80	65	4.6
MdRH-MC3, 9.5 µg/L	11.3	11.3	26	3.8
MdRH-MC3, 13 µg/L	13.9	14.1	4	1.8
MdRH-MC3, 17 µg/L	17.1	18.2	6	2.3
MdRH-MC3, 23 µg/L	23.4	23.2	4	2.7
MdRH-A, 0 µg/L	7.50	8.27	71	6.5
MdRH-A, 3 µg/L	10.3	10.4	29	7.0
MdRH-A, 4 µg/L	11.0	11.2	21	10.0
MdRH-A, 5.5 µg/L	12.3	12.4	8	6.2
MdRH-A, 7.0 µg/L	13.4	13.7	8	5.8
MdRH-A, 9.5 µg/L	15.8	15.4	3	1.0
MdRH-A, 13 µg/L	18.6	18.4	5	0.9
MdRH-A, 17 µg/L	22.0	20.9	3	2.8
MdRH-A dup, 0 µg/L	7.53	7.74	75	5.7
MdRH-A dup, 3 µg/L	9.08	10.0	33	10.3
MdRH-A dup, 4 µg/L	10.7	10.8	37	13.2
MdRH-A dup, 5.5 µg/L	11.4	11.8	13	4.3
MdRH-A dup, 7.0 µg/L	12.5	23.4	10	7.4
MdRH-A dup, 9.5 µg/L	15.0	15.0	5	2.5
MdRH-A dup, 13 µg/L	20.5	18.2	3	1.6
MdRH-A dup, 17 µg/L	22.5	21.8	4	2.0
MdRH-B, 0 µg/L	6.88	6.91	85	3.6
MdRH-B, 3 µg/L	9.79	9.72	55	9.0
MdRH-B, 4 µg/L	10.5	10.1	33	8.7
MdRH-B, 5.5 µg/L	11.4	11.4	22	7.7

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean)	Standard Deviation
MdRH-B, 7.0 µg/L	12.9	12.6	14	5.5
MdRH-B, 9.5 µg/L	14.6	14.4	5	2.4
MdRH-B, 13 µg/L	18.3	17.1	5	2.3
MdRH-B, 17 µg/L	21.2	20.0	3	1.3
MdRH-E, 0 µg/L	10.1	9.72	38	9.3
MdRH-E, 3 µg/L	12.3	12.3	11	6.8
MdRH-E, 4 µg/L	13.2	13.2	5	3.1
MdRH-E, 5.5 µg/L	14.9	14.2	7 ^a	2.6 ^a
MdRH-E, 7.0 µg/L	16.1	15.1	4 ^a	3.6 ^a
MdRH-E, 9.5 µg/L	17.0	17.1	6 ^a	1.6 ^a
MdRH-E, 13 µg/L	20.4	19.6	8 ^a	4.9 ^a
MdRH-E, 17 µg/L	24.6	23.1	1 ^a	1.0 ^a
MdRH-F, 0 µg/L	6.87	7.13	78	5.5
MdRH-F, 3 µg/L	9.39	9.27	54	5.9
MdRH-F, 4 µg/L	11.3	10.6	40	8.1
MdRH-F, 5.5 µg/L	12.2	11.4	17	8.2
MdRH-F, 7.0 µg/L	13.6	12.4	9	5.2
MdRH-F, 9.5 µg/L	16.0	14.2	3	1.0
MdRH-F, 13 µg/L	19.3	17.0	4	2.9
MdRH-F, 17 µg/L	22.2	19.9	2	1.5

^aN=2

Table 6. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results		Biotic Ligand Model Predictions		
	Copper EC50 (µg/L)	Calculated WER	Copper EC50 (µg/L)	Calculated WER	
Granite Canyon	10.07		7.19		
MdRH-MC3	10.03	1.00	8.89	1.24	
MdRH-A	9.68	0.96	11.80	1.64	1.54 (mean)
MdRH-A duplicate	8.95	0.89		10.28	
MdRH-B	10.18	1.01	10.48	1.46	
MdRH-E	< 10.1 ^a	--	9.07	1.26	
MdRH-F	10.95	1.09	8.55	1.19	
Geometric mean		0.99 ^b		1.36	

^aEC50 values could not be calculated due to high toxicity in dose-response range.

^bGeometric mean calculated using MdRH-MC3, -A, -A duplicate, -B, and -F.

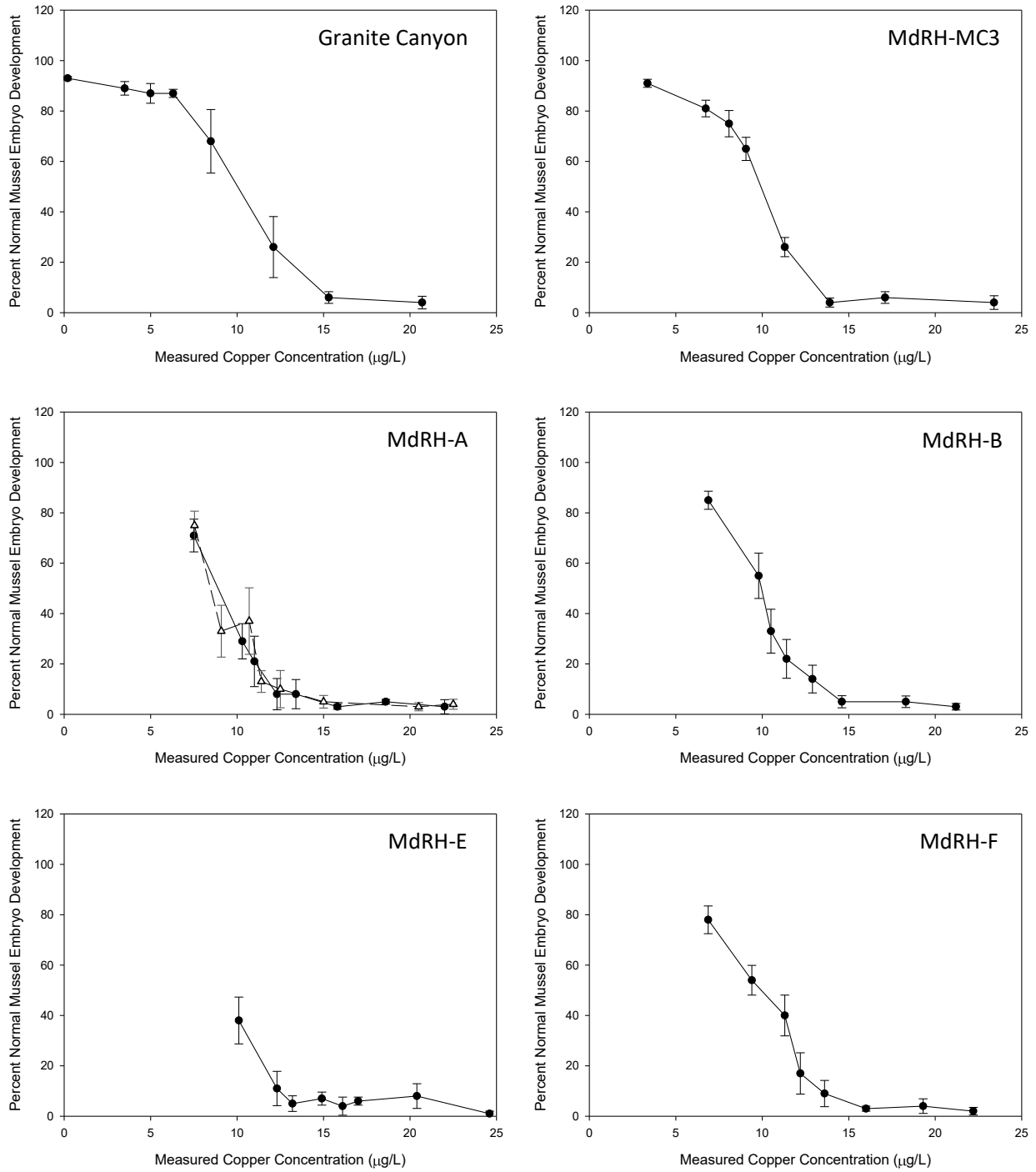


Figure 3. Dose response curves for reference water and field samples. MdRH-A (circles) and MdRH-A dup (triangles) are plotted together.

References

Al-Reasi, H.A. and D.S. Smith. 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.

Tait, T.N., C.A. Cooper, J.C. McGeer, C.M. Wood, and D.S. Smith. 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.

USEPA. 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

APPENDIX C-7: WER SAMPLING EVENT 7 RESULTS SUMMARY: WINTER DRY WEATHER, SPRING TIDE

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February 18, 2021

Introduction

For the Marina del Rey Harbor Site-Specific Objective Study, the Technical Advisory Committee (TAC), SCCWRP, and stakeholders developed a Workplan which includes six successful WER sampling events. These different sampling events are designed to capture a range of conditions in the Harbor including wet and dry weather periods as well as spring and neap tides. Sampling includes spatial compositing (three samples from each basin) as well as tidal range composites (flood and ebb tide), in order to capture representative samples. This report summarizes the seventh WER event, which covers the winter dry weather, spring tide sampling event.

Study Design and Methods

Sampling occurred at one depth (1 m below the water surface) for 5 station locations in MdrH (Figure 1). For each basin station, three subsamples (inner, mid, and outer basin) were taken and composited. A single sample was taken for the main channel station. This sampling was repeated once more such that a spatially representative sample was taken during both flood and ebb tide. Once all sampling was complete, these two samples were composited to create one final sample per station. This sample was subsampled for chemical analysis (total and dissolved metals and dissolved organic carbon [DOC]) and toxicity testing. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and salinity were measured and recorded in the field. For basin stations, water quality parameters were measured at each subsample location (inner, mid, and outer). A duplicate sample for all parameters was taken at station MdrH-B. All field measurements and observations were performed as detailed in the Quality Assurance Project Plan (QAPP), Attachment A, Section 5 “Field measurements and observations”.

After sample collection, the final sample composites were subsampled for metals and DOC while still in the field. The dissolved metals and DOC subsamples were each filtered through a 0.45 μm polyethersulfone (PES) syringe filter. Prior to sample filtration, an initial 10-20 mL of Milli-Q water was used to rinse the syringe. An additional 50 mL of Milli-Q water was passed through the syringe filter and discarded. The sample was then filtered, and the first 10 mL of sample filtrate was discarded. A new filter was used for each sample and analysis type and the same pre-rinsing technique was applied. All samples were stored on ice and taken back to the laboratory. The metals samples were stored at 4 °C overnight. Samples were delivered to Physis Environmental Laboratories, Inc. for analysis using the USEPA 1640 method as indicated in the Workplan. The quantitative DOC samples were acidified and stored at 4°C for no longer than one week prior to analysis at SCCWRP. The qualitative DOC samples were brought back to the laboratory and the absorbance (at 340 nm) was measured within 24 hours of sample filtration.

The sample collection bottles were purchased certified “pre-cleaned” from Environmental Sampling Supply (ESS). Glass vials for DOC were cleaned and kilned to remove any organic material prior to use. The centrifuge tubes used for total and dissolved metals were purchased new with no pre-cleaning performed. Syringes and filters were individually packaged and sterile.

For the toxicity testing, field samples were run through a 20-micron Nitex mesh to remove potential predators. A copper dose-response was created by spiking field samples and Granite Canyon control water with varying levels of copper. An initial copper stock solution was made (10,000 µg Cu/L Milli-Q water) using copper (II) chloride dihydrate. A working solution of 1000 µg Cu/L was made by diluting the stock using Granite Canyon water. An appropriate volume of this working solution was used to create 250 mL of each dose response concentration for the Granite Canyon reference water and each composited field sample (Table 1). The spiked samples were mixed by bottle inversion several times and allowed to equilibrate at 4°C for at least 12 hours. The bottles were mixed by inversion again prior to their addition to the exposure chambers. Subsamples of each dose from day 0 and day 2 were filtered and saved for dissolved metals analysis using the same filtration method described for the field samples. These samples were delivered to Physis along with the total and dissolved metals samples from the field.

Toxicity in the field samples and the Granite Canyon control water was measured by the 48-hour mussel embryo development test using *Mytilus galloprovincialis* (USEPA 1995). The endpoints for this test included normal embryo development and survival. This test was a static non-renewal toxicity test run at 15°C ± 1 °C for 48 hours. The exposure was performed in glass shell vials with a 10 mL sample volume and approximately 250 embryos. For this study, the test was run using five replicates per treatment. At the start of the test, embryos were added to five extra control vials which were immediately preserved and counted to determine the average number of initial embryos added to the test chambers. At test termination, all vials were preserved and saved for microscopic evaluation. Each vial was evaluated by counting the number of normal and abnormal embryos. Percent normal was calculated by dividing the number of normal embryos by the sum of the normal and abnormal embryos and multiplying that by 100.

Water effect ratios were calculated using two types of data: the water quality data with the Biotic Ligand Model (BLM), and the toxicity test results. The water quality data (pH, temperature, salinity) from the un-spiked samples during the toxicity test breakdown and the measured DOC concentration from the field samples were used in the biotic-ligand model (BLM, Windward v3.16.2.41) to calculate a predicted EC50 for *Mytilus galloprovincialis* for each sample. The predicted EC50 for each field sample was divided by the predicted EC50 for the Granite Canyon water sample. This is the BLM-based WER. These calculations provide a comparison between the model and laboratory-based results. The toxicity test results (percent normal embryos) and measured dissolved copper concentrations were used to create dose-response curves and calculate EC50 values for each station. These calculations were performed using CETIS (v1.9.0.8). These calculated EC50 values for each site were divided by the EC50 value from the Granite Canyon water to determine the toxicity-based WER. The general WER equation is below:

$$\text{WER} = \text{EC50 Site water} / \text{EC50 Granite Canyon Water}$$

Table 1. Nominal copper dose-response concentrations.

Granite Canyon and MC3 samples (µg/L)	Basin Samples (µg/L)
0.0	0.0
4.0	3.0
5.5	4.0
7.0	5.5
9.5	7.0
13	9.5
17	13
23	17

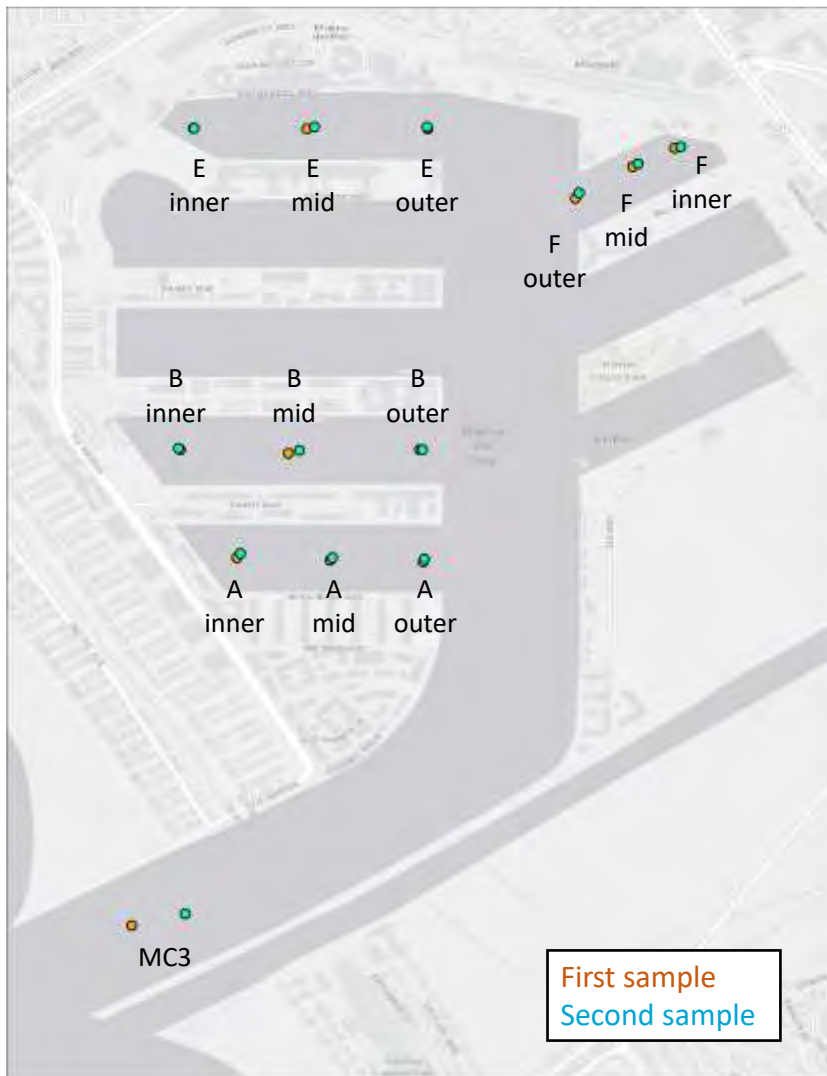


Figure 1. Station locations sampled in Marina del Rey Harbor.

Results

Sampling

Sampling occurred on Thursday, December 10, 2020. This sampling event constituted the winter dry weather, spring tide sample collection. The last recorded rainfall (0.03 in) occurred on November 7, 2020. Sampling times were related to tide heights based on the Mean Lower Low Water (MLLW), which is the average of the lower low water height of the tidal day (Figure 2). These data were retrieved from NOAA's Tides and Currents website for the Santa Monica location (<https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410840>). The first sample (MdrH-MC3) was taken approximately 1.5 hours after the high tide (+5.93 ft) at +5.06 ft, and the final sample (MdrH-F) was taken approximately 3 hours after the low tide (+0.64 ft) at +2.26 ft. The overall tide change for the sampling window was +4.42 ft.

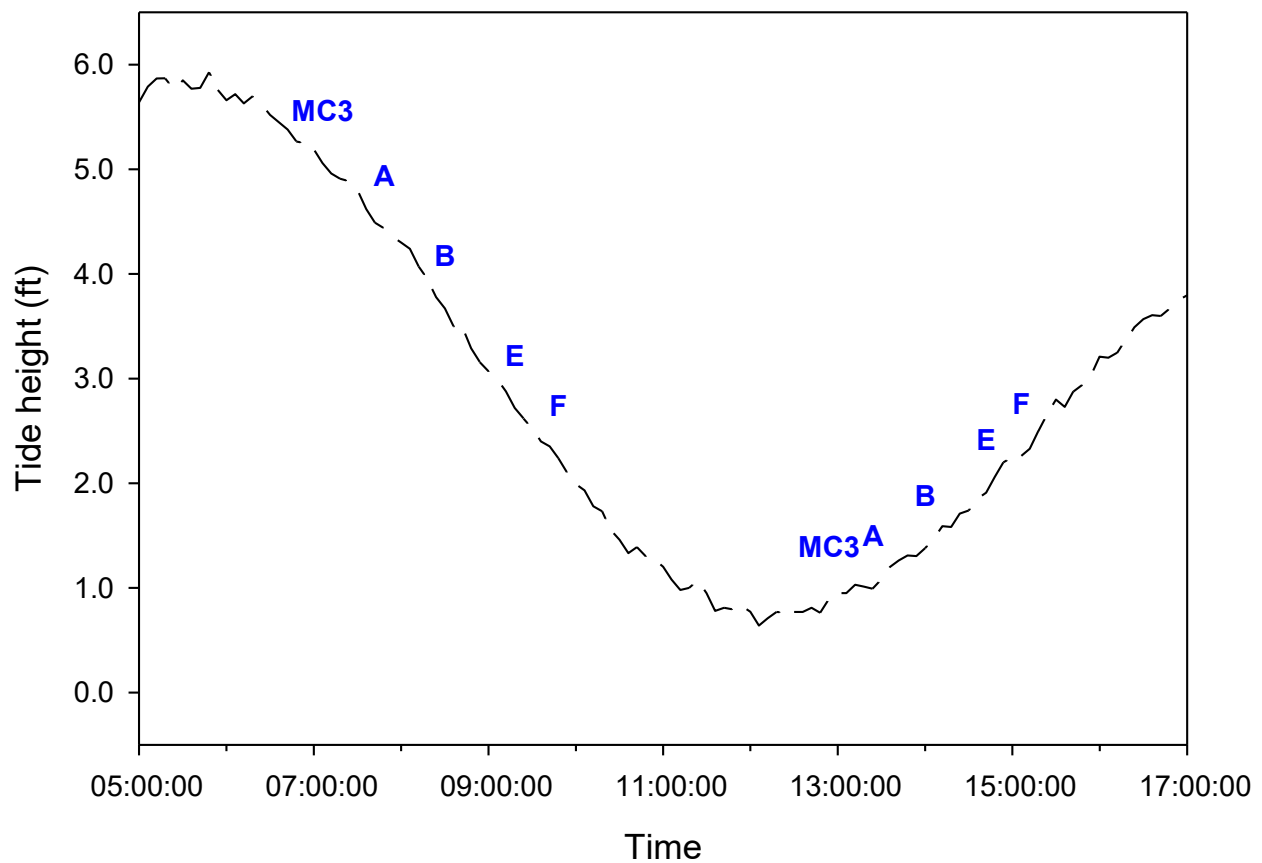


Figure 2. Sample collection times relative to tide height.

Water Quality Analysis

A summary of the bulk sample water quality results and metals concentrations are reported in Tables 2 and 3. In response to the Los Angeles Regional Board's request, field measurements were recorded for subsampled basin locations (inner, mid, and outer). For all stations, the

measurements exhibited little variation among subsamples, indicating little spatial variability within each basin. The pH values ranged from 7.77 to 8.05, with no clear spatial trends. Mean sample temperature generally increased between the morning (14.6°C) and afternoon (15.4°C) samples, with the lowest temperature observed for the MC3 morning sample (13.6°C).

Dissolved copper concentrations for all stations exceeded the water quality criteria (3.1 µg/L) and ranged from 3.51 µg/L (MdrH-MC3) to 17.8 µg/L (MdrH-A). Basins B (14.8-15.6 µg/L) and E (14.4 µg/L) had similar dissolved copper concentrations and were in between the concentrations measured in Basins A and F (12.5 µg/L). For the basin locations, these dissolved copper concentrations were 1.3-2.2 times higher than those observed for the previous winter dry weather event (WER 6 in November 2020). The lowest concentration was observed at MdrH-MC3 (3.51 µg/L).

The highest DOC concentration was in Basin B (0.98 mg/L) and the lowest concentration was in Basin F (0.68 mg/L), with no clear spatial trend between the main channel, and front and back basins. The DOC concentration range (0.33 mg/L) was similar to the previous wet weather and winter dry weather WER events, which was greater compared to the range of summer dry weather MdrH samples (0.15-0.20 mg/L range). The DOC concentrations for this event (0.65-0.98 mg/L) were lower than the neap tide winter dry weather event (WER 6, 1.16-1.59 mg/L) by a factor of 1.4-2.4.

In addition to the quantitative analysis of DOC, a subsample (10-20 mL) of the filtrate was taken for qualitative analysis. Spectrophotometric characterization of the subsample was performed to determine the specific absorbance coefficient at 340nm (SAC340), which is an indicator of DOC aromaticity (Tait et al. 2016, Table 4). Typically, more aromatic, terrestrially-derived DOC is darker in color with a greater absorbance, and less aromatic, microbially-derived DOC is lighter in color. Based on the source and characterization of seven DOM isolates by Al-Reasi et al. (2012), they found SAC340 values for microbially-derived DOC in the range of 4-15, and terrestrially-derived DOC in the range of 28-40. These are not set thresholds for the two categories of DOC, but rather provide more context for data interpretation.

$$\text{SAC340} = 2303 (\text{Abs340}/\text{DOC})$$

Abs340 is the sample absorbance at 340 nm and DOC is the concentration in mg/L.

All the Harbor samples had relatively similar absorbance values that ranged from 0.0033 (MdrH-MC3) to 0.0043 (MdrH-B dup and -E). Granite Canyon had the lowest absorbance (0.0028) value. The resulting SAC340 values ranged from 9.0 (MdrH-MC3) to 14.1 (MdrH-F). All the stations fell within the microbially-derived DOC range (4-15), suggesting microbially-sourced DOC was the primary source. This is consistent with the expectations for dry weather sampling and are similar to the SAC340 values reported for the previous dry weather sampling events.

Quality assurance (QA) review of the results, including precision, accuracy, and sensitivity, followed those detailed in the QAPP. All field probes were calibrated and checked according to the methods and QA verification sheet outlined in the QAPP Attachment A. For this sampling event, dissolved copper and zinc were detected in the tubing blank (0.277 µg Cu/L and 0.333 µg Zn/L). However, these values were 1-2 orders of magnitude lower than the field samples. These low concentrations plus the process of flushing the site water thorough the tubing before and

between sample collection minimizes the impact of these blank concentrations. Results and methods presented here were consistent with the QAPP, with two exceptions: 1) DOC data should be qualified. Although laboratory blanks, matrix spikes, lab duplicates, and field duplicates all met data quality objectives for precision, accuracy assessments using certified reference materials did not. The DOC certified reference material was measured at 0.80 mg/L, 0.05 mg/L below the acceptable range (0.85-0.90 mg/L), suggesting a low bias in the results; 2) A thermometer was not included in the cooler of metals samples. However, these samples were packed in a cooler with ice and sent directly to Physis Laboratories via personal courier. The temperature measured upon receipt was 3.1°C for the field and Day 0 toxicity samples and 2.9°C for the Day 2 toxicity samples indicating these samples were kept under acceptable conditions during transit.

Table 2. Field measurements from the WER #7 sampling event on December 10, 2020.

Composite	Station	Basin Location	Sample Start Time	Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)	
First	MdRH-MC3	--	0707	5.06	8.05	34.3	13.6	6.51	
	MdRH-A	Inner	0735	4.62	7.86	34.0	14.2	6.14	
		Mid	0747	4.44	7.85	34.0	14.4	6.30	
		Outer	0757	4.30	7.86	34.0	14.5	6.79	
	MdRH-B	Inner	0815	3.95	7.81	33.5	14.3	5.84	
		Mid	0830	3.67	7.81	34.0	14.4	5.93	
		Outer	0843	3.49	7.84	34.0	14.7	6.55	
	MdRH-B Dup	Inner	0815	3.95	7.82	34.0	14.2	6.05	
		Mid	0830	3.67	7.81	34.0	14.5	6.02	
		Outer	0843	3.49	7.84	34.0	14.6	6.72	
	MdRH-E	Inner	0906	2.99	7.83	33.6	15.2	6.78	
		Mid	0917	2.72	7.82	33.4	14.7	6.48	
		Outer	0928	2.52	7.84	33.6	15.2	7.02	
	MdRH-F	Inner	0942	2.35	7.78	33.8	15.1	6.66	
		Mid	0950	2.24	7.78	33.9	15.1	6.78	
		Outer	0959	1.99	7.77	33.8	15.4	6.63	
	Second	MdRH-MC3	--	1256	0.89	7.85	34.0	15.7	7.38
		MdRH-A	Inner	1317	1.01	7.79	34.0	15.0	6.64
Mid			1326	0.99	7.80	33.9	15.2	6.70	
Outer			1335	1.20	7.81	33.9	15.4	6.95	
MdRH-B		Inner	1351	1.30	7.79	34.0	15.7	6.84	
		Mid	1400	1.38	7.79	34.0	15.5	6.89	
		Outer	1410	1.59	7.79	34.0	15.5	6.84	
MdRH-B Dup		Inner	1351	1.30	7.79	34.0	15.3	6.92	
	Mid	1400	1.38	7.80	34.0	15.3	6.92		

Composite	Station	Basin Location	Sample Start Time	Mean Tide Height (ft)	pH	Salinity (ppt)	Temp (°C)	DO (mg/L)
		Outer	1410	1.59	7.80	33.9	15.3	7.00
	MdRH-E	Inner	1431	1.74	7.83	33.6	15.4	7.17
		Mid	1440	1.91	7.82	33.6	15.4	7.11
		Outer	1449	2.06	7.80	33.5	15.6	6.94
	MdRH-F	Inner	1501	2.25	7.77	33.7	15.6	6.81
		Mid	1508	2.33	7.79	33.9	15.5	6.78
		Outer	1515	2.50	7.78	33.8	15.4	6.67

DO-Dissolved oxygen

Dup-duplicate sample

Table 3. Chemistry results from the WER #7 sampling event on December 10, 2020.

Station	DOC (mg/L)	Total Cu (µg/L)	Diss. Cu (µg/L)	Total Zn (µg/L)	Diss. Zn (µg/L)
MdRH-MC3	0.84	4.64	3.51	22.7	20.9
MdRH-A	0.65	19.9	17.8	105	101
MdRH-B	0.97	16.0	15.6	102	106
MdRH-B Dup	0.98	16.0	14.8	105	102
MdRH-E	0.75	16.1	14.4	123	118
MdRH-F	0.68	14.2	12.5	95.7	88.5
QA Samples					
Tubing blank	< 0.055	0.390	0.277	0.648	0.333
Travel blank	--	0.029	--	ND	--
Field blank	< 0.055	0.016	ND	ND	ND
Filter blank 1	< 0.055	--	--	--	--
Filter blank 2	< 0.055	--	--	--	--
Filter blank 3	< 0.055	--	--	--	--
DOC matrix spike recovery	110%				
DOC CRM	0.80	below range (0.85-0.90)			

Diss.-Dissolved

DOC-Dissolved organic carbon

Zn-Zinc

Cu-Copper

Dup-duplicate sample

ND-Not detected

Table 4. Dissolved organic carbon characterization results.

Station	DOC (mg/L)	Abs @ 340nm	SAC ₃₄₀
MdRH-MC3	0.84	0.0033	9.00
MdRH-A	0.65	0.0039	13.6
MdRH-B	0.97	0.0042	9.98
MdRH-B Dup	0.98	0.0043	10.1
MdRH-E	0.75	0.0043	13.3
MdRH-F	0.68	0.0042	14.1
Granite Canyon	0.61	0.0028	10.3

SAC₃₄₀ = 2303 (Abs₃₄₀/DOC)

WER Results

The test acceptability criteria for the mussel embryo development test require the control to have a mean survival of at least 50%, percent normal development of at least 90%, and a percent minimum significant difference (MSD) of less than 25%. This toxicity test met two of the three criteria with 117% survival in the Granite Canyon control and a mean percent normal development of 91%; however, the MSD was 31% for the Granite Canyon control, which failed the test acceptability criteria. This is likely due to the high variability observed in a few of the spiked treatment groups.

The dissolved copper concentrations measured in the dose-response samples (Day 0 and Day 2) and the corresponding toxicity test results (percent normal mussel embryos and replicate standard deviation) are summarized in Table 5. Overall, dissolved copper concentrations changed little during the test duration. The average percent difference across all samples and doses was approximately 4%. For the toxicity test groups for basin samples, replicate variability was similar to previous WERs with standard deviations ranging from 0-8%, with 0% (0 out of 40) of the treatments having replicate standard deviation values exceeding 10. For the Granite Canyon and MC3 treatment groups, the standard deviations ranged from 0.7-223%, with 38% (6 out of 16) of the treatments having replicate standard deviation values exceeding 10. For the higher spiked basin samples (5.5 µg/L and above), only two of the five replicates were counted due to the high toxicity response. The percent normal values were less than 10% at lesser copper concentrations, minimizing the need for toxicity data at higher copper concentrations.

Toxicity was observed in all un-spiked basin samples, which has not been observed in the prior summer dry weather and wet weather WER events. For example, the toxicity observed in the basins for this event (8-25% normal development) was greater than that observed in the previous winter dry weather event (WER 6, 38-85% normal development). We cannot confirm the responsible toxicant for these samples because no toxicity identification evaluation was conducted.

Test animal sensitivity was within the range of previous WER events. The average percent normal response in the un-spiked Granite Canyon reference water in this event (91%) was

similar to the control response observed in previous tests (91-96%). The calculated dissolved copper EC50 value for the Granite Canyon reference water (7.45 µg/L) was within the range of values observed in previous tests (6.89-10.07 µg/L), which indicates similar sensitivity of test organisms to copper compared to the previous WER events.

The dose-response curves and EC50 values for each station were calculated using CETIS (v1.9.0.8) (Figure 3, Table 6). The water effect ratio for the main channel was calculated using the Granite Canyon reference water EC50 as the reference result (Table 6). An EC50 value and WER could not be calculated for any of the basin locations as the toxicity in all concentrations was too high (< 50% normal development). The MC3 WER was 1.27, which is similar to the WERs observed in the summer dry weather events (WERs 1 and 2).

In addition to the toxicity-based WERs, the Biotic Ligand Model (BLM) was used to estimate EC50 and WER values for each sample (Table 6). These predictions were generated using the measured DOC concentrations as well as the day 2 water quality values from the laboratory toxicity test. This was done to ensure comparable conditions for both the laboratory- and model-based EC50 results. The day 0 water quality measurements were taken prior to addition of the test organisms, and the day 2 water quality measurements were taken upon test breakdown and most accurately reflect the test conditions. The Granite Canyon reference water and MC3 had greater measured EC50 values compared to the modeled values, a pattern which is consistent with previous events. This was also reflected in the WER values, with the modeled MC3 WER (1.37) slightly higher than the measured WER (1.27). The BLM-based WERs ranged from 1.07 (MdrRH-A) to 1.59 (MdrRH-B Dup), and the geometric mean was 1.31.

Table 5. WER copper concentrations and toxicity test data.

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean of n=5 unless noted)	Standard Deviation
SCCWRP lab seawater	--	--	74	40
GC, 0 µg/L	0.41	0.90	91	1.6
GC, 4 µg/L	3.66	3.84	80	18
GC, 5.5 µg/L	4.74	4.72	43	43
GC, 7.0 µg/L	6.31	6.21	60	33
GC, 9.5 µg/L	8.27	8.64	55	9.5
GC, 13 µg/L	11.6	11.7	12 (n=4, 1 spilled)	5.5
GC, 17 µg/L	14.4	15.6	4	1.2
GC, 23 µg/L	20.4	20.9	3	2.3
MdRH-MC3, 0 µg/L	2.34	2.42	76	38
MdRH-MC3, 4 µg/L	5.80	5.44	67	34
MdRH-MC3, 5.5 µg/L	6.48	6.80	78	7.4
MdRH-MC3, 7.0 µg/L	7.62	7.50	62	7.3
MdRH-MC3, 9.5 µg/L	9.55	10.1	42	223
MdRH-MC3, 13 µg/L	12.1	12.2	6	3.8
MdRH-MC3, 17 µg/L	15.7	15.3	3	0.7
MdRH-MC3, 23 µg/L	20.5	21.1	3	1.1
MdRH-A, 0 µg/L	12.7	12.8	9	6.7
MdRH-A, 3 µg/L	14.4	15.2	4	2.7
MdRH-A, 4 µg/L	16.3	16.1	4	3.2
MdRH-A, 5.5 µg/L	17.6	17.0	3 (n=2)	2.0
MdRH-A, 7.0 µg/L	12.6	13.1	5 (n=2)	2.7
MdRH-A, 9.5 µg/L	20.7	21.1	1 (n=2)	0.9
MdRH-A, 13 µg/L	24.2	23.2	1 (n=2)	0.5
MdRH-A, 17 µg/L	27.1	27.1	2 (n=2)	2.5
MdRH-B, 0 µg/L	12.5	13.3	12	8.2
MdRH-B, 3 µg/L	15.1	15.9	4	1.5
MdRH-B, 4 µg/L	16.1	16.3	3	2.1
MdRH-B, 5.5 µg/L	17.7	18.1	8 (n=2)	1.2
MdRH-B, 7.0 µg/L	18.8	19.4	1 (n=2)	0.4
MdRH-B, 9.5 µg/L	20.4	21.1	3 (n=2)	4.0
MdRH-B, 13 µg/L	23.5	23.9	3 (n=2)	0.4
MdRH-B, 17 µg/L	25.4	26.5	0 (n=2)	0.0
MdRH-B dup, 0 µg/L	14.3	12.5	9	6.6
MdRH-B dup, 3 µg/L	15.5	15.2	2	0.6
MdRH-B dup, 4 µg/L	15.4	15.3	3	1.4
MdRH-B dup, 5.5 µg/L	16.9	16.9	2 (n=2)	0.7

Station and nominal copper spike	Day 0 Diss. Cu (µg/L)	Day 2 Diss. Cu (µg/L)	Mussel embryo %Normal (mean of n=5 unless noted)	Standard Deviation
MdRH-B dup, 7.0 µg/L	18.3	18.1	1 (n=2)	0.8
MdRH-B dup, 9.5 µg/L	20.5	19.3	3 (n=2)	2.0
MdRH-B dup, 13 µg/L	22.9	22.5	1 (n=2)	0.6
MdRH-B dup, 17 µg/L	26.9	26.2	2 (n=2)	2.1
MdRH-E, 0 µg/L	13.1	12.1	8	5.3
MdRH-E, 3 µg/L	14.7	14.6	5	2.1
MdRH-E, 4 µg/L	15.9	15.6	3	2.0
MdRH-E, 5.5 µg/L	16.8	16.1	7 (n=2)	6.0
MdRH-E, 7.0 µg/L	18.4	17.3	7 (n=2)	1.4
MdRH-E, 9.5 µg/L	20.7	19.5	2 (n=2)	1.0
MdRH-E, 13 µg/L	22.3	22.1	2 (n=2)	0.4
MdRH-E, 17 µg/L	27.7	25.2	2 (n=2)	1.3
MdRH-F, 0 µg/L	11.1	10.5	25	11
MdRH-F, 3 µg/L	14.1	13.3	5	4.0
MdRH-F, 4 µg/L	13.8	13.4	3	1.2
MdRH-F, 5.5 µg/L	18.3	17.6	3 (n=2)	0.3
MdRH-F, 7.0 µg/L	17.0	15.7	4 (n=2)	1.0
MdRH-F, 9.5 µg/L	18.6	18.2	1 (n=2)	1.7
MdRH-F, 13 µg/L	21.7	21.3	2 (n=2)	1.0
MdRH-F, 17 µg/L	24.7	23.4	1 (n=2)	0.7

Table 6. Toxicity test and Biotic Ligand Model (BLM) copper EC50 values and calculated WERs.

Station	Laboratory Toxicity Test Results		Biotic Ligand Model Predictions	
	Copper EC50 (µg/L)	Calculated WER	Copper EC50 (µg/L)	Calculated WER
Granite Canyon	7.45		4.56	
MdRH-MC3	9.46	1.27	6.24	1.37
MdRH-A ^a	--	--	4.88	1.07
MdRH-B ^a	--	--	7.20	1.58
MdRH-B duplicate ^a	--	--	7.24	1.59
MdRH-E ^a	--	--	5.53	1.21
MdRH-F ^a	--	--	5.06	1.11
Geometric mean ^b		--		1.31

^aEC50 values could not be calculated due to high toxicity in dose-response range.

^bA geometric mean was not calculated due to minimal data.

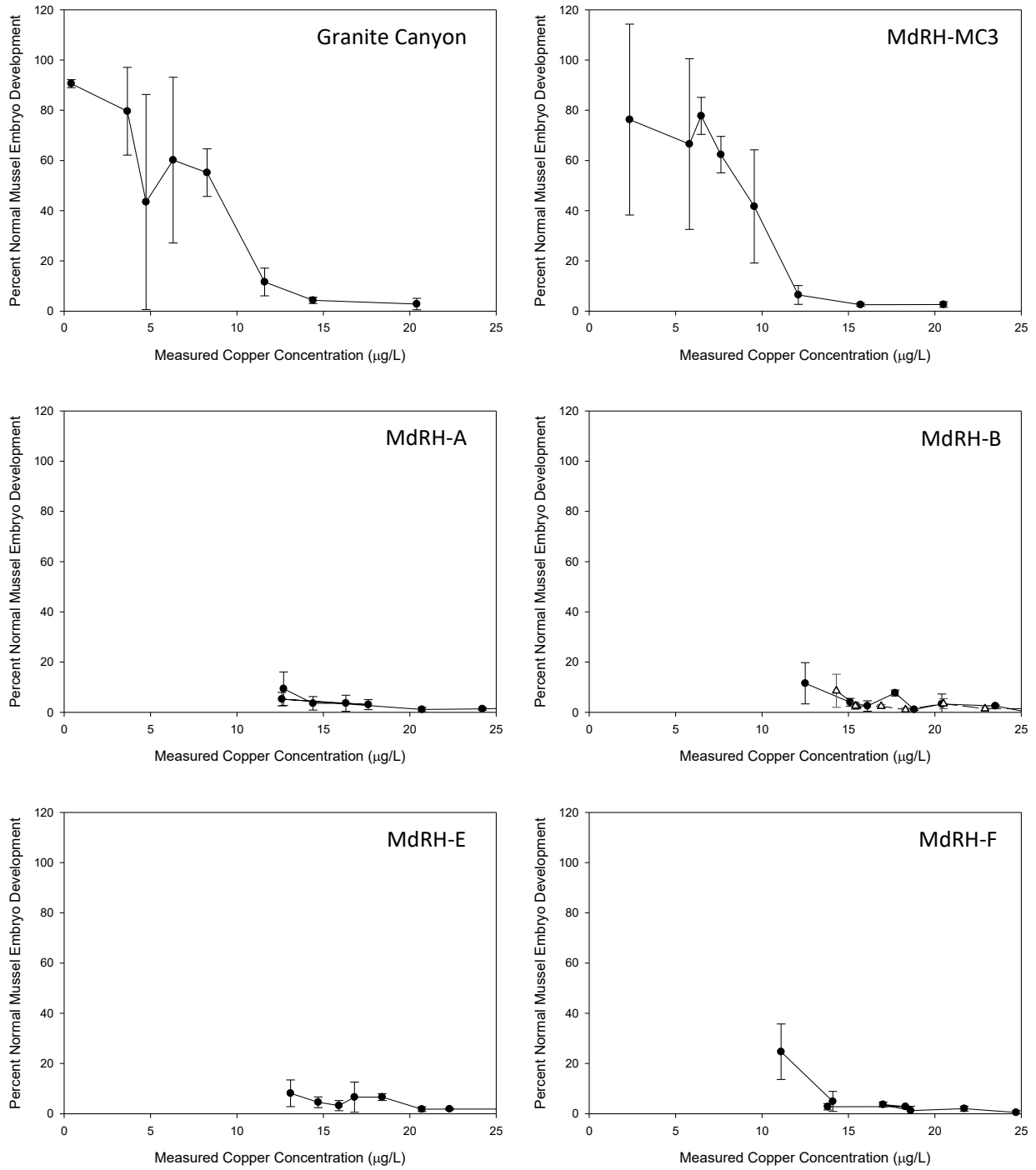


Figure 3. Dose response curves for reference water and field samples. MdRH-B (circles) and MdRH-B dup (triangles) are plotted together.

References

Al-Reasi, H.A. and D.S. Smith. 2012. Evaluating the ameliorative effect of natural dissolved organic matter (DOM) quality on copper toxicity to *Daphnia magna*: Improving the BLM. *Ecotoxicology*, 21:524-537.

Tait, T.N., C.A. Cooper, J.C. McGeer, C.M. Wood, and D.S. Smith. 2016. Influence of dissolved organic matter (DOM) source on copper speciation and toxicity to *Brachionus plicatilis*. *Environmental Chemistry*, 13:496-506.

USEPA. 1995. Short-term Methods of Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms. USEPA 600/R-95-136. National Exposure Research Laboratory, Office of Research and Development, Cincinnati, Ohio. August 1995.

APPENDIX D: 2019 MDRH SALINITY PROFILE SAMPLING

Introduction

During the December 2018 Technical Advisory Committee (TAC) meeting, the TAC suggested collecting more data regarding the impact of rain events on salinity in Marina del Rey Harbor (MdRH) waters. The objective is to determine if a salinity gradient was present after a rain event and if so, how long it takes for salinity values to return to normal. This data will better inform the wet weather sampling window as well as the appropriate antecedent period for a dry weather event.

Approach

Sampling occurred over two storm events. For both events, samples were collected from Basins E (MdRH-E) and H (MdRH-H), as well as one main channel location (MdRH-MC2; Table 1). Salinity and temperature measurements were taken at the surface as well as 1-, 2-, 3-, and 4-ft below the surface. Sampling was initiated within 24 hours of the end of a storm event and continued until no freshwater influence remained or up to four days post-storm.

Table 1. Station location coordinates within Marina del Rey Harbor.

Station ID	Description	Latitude	Longitude
MdRH-MC2	Main Channel, middle	N 33° 58.330'	W 118° 26.892'
MdRH-E	Back Basin E, middle	N 33° 58.977'	W 118° 27.191'
MdRH-H	Front Basin H, middle	N 33° 58.584'	W 118° 26.676'

Results

Rain Event #1

The total rainfall (3.96 inches) from January 12, 2019 through January 17, 2019 is summarized in Table 2. Salinity measurements were taken in Basins E and H as well as one Main Channel location on 1, 2, and 4 days post-rain at the five sample depths (Table 3). After the rain event, the salinity was reduced at all sample depths, with the lowest salinity reported for the surface samples. This depth-based salinity gradient was no longer observed at four days post-rain.

Table 2. Rainfall amounts for January 12-17, 2019 and dates of salinity measurements (indicated by x).

	1/12/2019	1/13/2019	1/14/2019	1/15/2019	1/16/2019	1/17/2019	1/18/2019	1/19/2019	1/20/2019	1/21/2019
Rain (in)	0.76	0	1.53	0.5	0.56	0.61				
Salinity Test							x	x		x

Table 3. Salinity measurements over time at MDRH-E, -H, and -MC2 for surface water (S) and 1, 2, 3, and 4 ft below the surface.

Average Sal (psu)															
Date	MDRH-E-S	MDRH-E-1	MDRH-E-2	MDRH-E-3	MDRH-E-4	MDRH-H-S	MDRH-H-1	MDRH-H-2	MDRH-H-3	MDRH-H-4	MDRH-MC2-S	MDRH-MC2-1	MDRH-MC2-2	MDRH-MC2-3	MDRH-MC2-4
1/18/2019	24.0	25.2	25.2	25.6	28.1	27.5	27.6	27.8	28.1	28.3	27.3	27.8	28.5	28.6	29.0
1/19/2019	29.2	29.1	29.2	29.3	30.4	30.4	30.3	30.3	30.5	30.7	29.9	29.9	29.9	30.2	30.2
1/21/2019	31.8	31.8	31.8	31.8	31.8	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	32.0	32.1

Rain Event #2

The total rainfall (3.13 inches) from January 31, 2019 through February 5, 2019 is summarized in Table 4. Salinity measurements were taken in Basins E and H as well as one Main Channel location on the final two days of the storm as well as 1- and 2-days post-rain at the five sample depths (Table 5). During and after the rain event, the salinity was reduced at all sample depths, with the lowest salinity frequently reported for the surface samples. During the rain event, the presence of a depth-based salinity gradient was variable among locations. At Basin E, a depth-based salinity gradient was present throughout the study period although salinity levels increased as the runoff plume mixed with harbor seawater. However, at Basins H and the main channel, a depth-based salinity gradient was only observed on the day following the storm (February 6).

Table 4. Rainfall amounts for January 31-February 5, 2019 and dates of salinity measurements (indicated by x).

	1/31/2019	2/1/2019	2/2/2019	2/3/2019	2/4/2019	2/5/2019	2/6/2019	2/7/2019
Rain (in)	0.99	0	1.34	0.26	0.41	0.13		
Salinity Test					x	x	x	x

Table 5. Salinity measurements over time at MdrH-E, -H, and -MC2 for surface water (S) and 1, 2, 3, and 4 ft below the surface.

Average Sal (psu)															
Date	MDRH-E-S	MDRH-E-1	MDRH-E-2	MDRH-E-3	MDRH-E-4	MDRH-H-S	MDRH-H-1	MDRH-H-2	MDRH-H-3	MDRH-H-4	MDRH-MC2-S	MDRH-MC2-1	MDRH-MC2-2	MDRH-MC2-3	MDRH-MC2-4
2/4/2019	19.7	19.4	20.3	21.8	22.8	23.8	23.8	23.8	23.8	23.8	24.5	24.7	24.8	24.9	24.9
2/5/2019	24.3	24.6	24.8	24.8	27.5	24.5	24.8	24.5	24.9	24.9	24.7	24.8	24.7	24.4	24.6
2/6/2019	25.8	26.0	27.2	29.9	31.3	27.3	27.6	28.5	30.1	30.6	27.4	27.9	29.0	30.5	31.3
2/7/2019	29.7	29.7	29.8	31.8	32.3	31.9	31.9	32.0	32.2	32.3	31.8	31.8	31.9	32.2	32.4

APPENDIX E: CIMP DOC DATA

Table 1. CIMP DOC data from April 2019 through February 2020.

Station	Sample Date	DOC concentration (mg/L)
MdRH-B	4/24/2019	1.23
MdRH-B Dup	4/24/2019	1.14
MdRH-D	4/24/2019	1.10
MdRH-F	4/24/2019	1.12
MdRH-H	4/24/2019	1.16
MdRH-MC	4/24/2019	1.14
MdRH-A	5/15/2019	1.13
MdRH-A Dup	5/15/2019	1.21
MdRH-C	5/15/2019	1.28
MdRH-E	5/15/2019	1.12
MdRH-G	5/15/2019	1.27
MdRH-MC	5/15/2019	1.22
MdRH-B	6/4/2019	1.10
MdRH-B Dup	6/4/2019	1.08
MdRH-D	6/4/2019	1.10
MdRH-F	6/4/2019	1.05
MdRH-H	6/4/2019	1.03
MdRH-MC	6/4/2019	1.06
MdRH-A	7/23/2019	0.87
MdRH-C	7/23/2019	0.88
MdRH-E	7/23/2019	0.90
MdRH-G	7/23/2019	0.85
MdRH-MC	7/23/2019	0.98
MdRH-MC Dup	7/23/2019	0.95
MdRH-B	8/6/2019	1.01

Station	Sample Date	DOC concentration (mg/L)
MdRH-D	8/6/2019	1.05
MdRH-F	8/6/2019	1.00
MdRH-H	8/6/2019	0.94
MdRH-H Dup	8/6/2019	0.93
MdRH-MC	8/6/2019	1.00
MdRH-A	9/11/2019	0.95
MdRH-C	9/11/2019	0.91
MdRH-E	9/11/2019	0.93
MdRH-E Dup	9/11/2019	0.98
MdRH-G	9/11/2019	0.94
MdRH-MC	9/11/2019	1.22
MdRH-B	10/22/2019	1.30
MdRH-D	10/22/2019	1.40
MdRH-D Dup	10/22/2019	1.40
MdRH-F	10/22/2019	1.40
MdRH-H	10/22/2019	1.40
MdRH-MC	10/22/2019	1.40
MdRH-A	11/13/2019	0.52
MdRH-C	11/13/2019	0.52
MdRH-C Dup	11/13/2019	0.44
MdRH-E	11/13/2019	0.53
MdRH-G	11/13/2019	0.49
MdRH-MC	11/13/2019	0.51
MdRH B	12/17/2019	0.85
MdRH-D	12/17/2019	1.09
MdRH-F	12/17/2019	0.77
MdRH-F Dup	12/17/2019	0.74
MdRH-H	12/17/2019	0.76

Station	Sample Date	DOC concentration (mg/L)
MdRH-MC	12/17/2019	0.96
MdRH-A	1/13/2020	0.72
MdRH-C	1/13/2020	0.91
MdRH-E	1/13/2020	0.83
MdRH-G	1/13/2020	0.55
MdRH-MC	1/13/2020	0.54
MdRH-MC Dup	1/13/2020	0.54
MdRH-B	2/19/2020	0.87
MdRH-D	2/19/2020	0.99
MdRH-F	2/19/2020	1.06
MdRH-H	2/19/2020	0.78
MdRH-H Dup	2/19/2020	0.79
MdRH-MC	2/19/2020	1.00