COASTAL ECOLOGY WORKPLAN SPECIAL STUDIES

SPECIAL STUDY 1

TITLE: Sediment profile imaging as a tool to assist coastal management
COLLABORATOR: Giancarlo Cicchetti, US EPA, Atlantic Ecology Division, Narragansett RI

Assemblages of soft-bottom organisms can be rich and diverse, with over 100 species and 1,000 individuals in a single square meter of ocean floor, and analyses of benthic infauna and sediment condition provide the most direct evidence of biological impairment in coastal waters. As a result, benthic infaunal monitoring has occurred in the southern California Bight (SCB) for nearly 40 years to help assess the impacts of human activities.

In an effort to reduce the complexity of benthic biological information, scientists have developed assessment indices such as the benthic response index (BRI). The BRI has become an assessment tool that environmental managers rely upon to help score and rank the biological condition of individual sites. The use of the BRI and related indices has become such a powerful tool that environmental managers have incorporated benthic infaunal analysis into State regulatory policy for assessing sediment quality.

Despite the utility of benthic infaunal analysis, one of the primary drawbacks to using benthic infaunal information is the tremendous effort required to analyze samples. Individual samples may take months (or longer) to analyze and may cost thousands of dollars. Certain technologies, however, may assist in benthic infaunal condition assessments. One example is the sediment profile imaging camera. The modern sediment profile camera (Figure 1, left) consists of a digital camera attached to an optical prism. The function of this prism is to cut into the sediment and photograph a sediment depth profile through an acrylic faceplate. When lowered to the

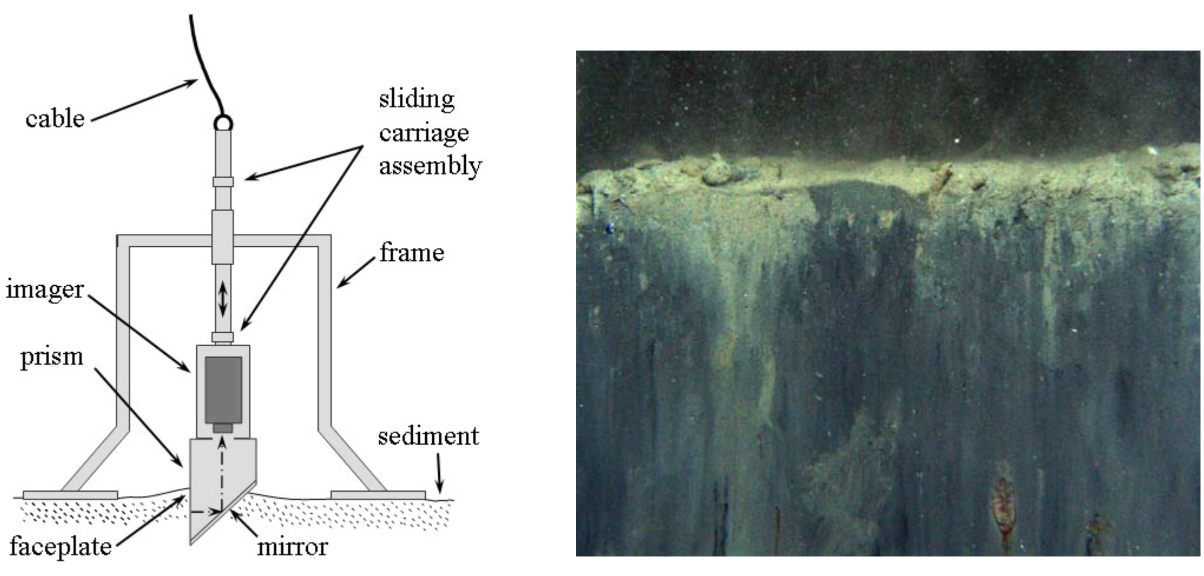

Figure 1. Sediment profile camera (left) and sediment profile image (right). Schematic of camera shows prism/carriage assembly that moves up or down relative to the frame so as to penetrate into the sediment and capture a picture. Image at right is 15 cm wide, taken in a Mid-Atlantic estuary. Infauna, animal tubes, and lighter oxidized sediments are visible.

sediment, the frame rests on top of the substrate and provides stability, while the weighted camera/prism assembly (or carriage) slides along the frame and penetrates into the sediment. The faceplate is then pressed up against the sediment itself, and provides a high resolution profile image (Figure 1, right) that is not affected by the clarity of the ambient water.

These images show structural aspects of benthic communities such as animal tubes, burrows, and feeding voids as well as the apparent Redox Potential Discontinuity (aRPD) depth. In general, however, sediment profile images cannot be used to identify benthic fauna beyond a crude taxonomic level. Previous studies in other locations have shown that indices developed for sediment profile data correlate well with indices of benthic macrofauna based on grab samples and animal counts when examining a full range of benthic condition from healthy to severely impaired. Sediment profile image indices generally do not provide the resolution of a locally-tuned benthic faunal index, but the sediment profile camera offers logistic advantages including rapid analysis and rapid deployment in a range of coastal habitats (e.g., estuaries, bays, coastal). These images also provide information on benthic function not available from faunal analyses.

The sediment profile camera has not been extensively used for environmental assessment in southern California, and the full utility of this technology has yet to be explored. The goal of this special study is test the ability of the camera to assist benthic assessment in southern California, and to develop approaches that combine camera information with faunal information to make best use of the advantages of each method. Three specific questions are:

1) Do sediment profile image data and indices correlate with benthic macrofaunal counts and indices in southern California?
2) Are sediment profile cameras a valuable tool for spatial mapping in areas of high interest?
3) Can the aRPD and other measures detected by sediment profile cameras support efforts to develop nutrient criteria?

The special study will consist of three tasks that mirror each of the above questions.

Task 1. Infaunal comparisons in bays, ports, marinas, estuaries, and lagoons

We will generate a dataset of sediment profile information to test for correlations with Bight '08 infaunal data. We will produce a report that 1) summarizes relationships between sediment profile and infaunal data, and 2) discusses faunal and imaging work as complementary approaches to assist assessment and management.

Task 2. Mapping a smaller high-interest area

We will collect sediment profile data to map a small high-interest area. We will write a report summarizing our findings and discussing ways that mapping based on sediment profile imaging can assist management of high-interest areas such as harbors, "hot spots", outfalls, etc.

Task 3. Applications in development of nutrient criteria

We will explore use of sediment profile data to: 1) characterize nutrient response variables (e.g., algal abundance, benthic response to low DO); and 2) rapidly estimate benthic function (bioturbation, biogeochemical rates, etc., via aRPD depths) for use in TMDL models. We will write a report describing use of imaging as a tool to assist with development of nutrient criteria.

SPECIAL STUDY 2

TITLE: Occurrence and levels of polybrominated diphenyl ethers (PBDEs) in sediments of the Southern California Bight

COLLABORATORS: John Christensen, Gunnar Lauenstein; NOAA/NOS/NCCOS, Silver Spring, MD

Brominated flame retardants (BFRs) are industrial chemical mixtures used extensively in the manufacture of clothing, furniture, and electronics. The introduction of BFRs during the 1970s was followed by its mass production and peak in widespread application over the next three decades. Over the past 10 years, there has been increasing global evidence of the bioaccumulation and biomagnification potential of BFRs, particularly in aquatic ecosystems. Compared with other parts of the U.S., very little data is available for the Southern California Bight (SCB) regarding the magnitude, extent, temporal trends or effects of BFR contamination, even though the State of California historically has among the strictest standards in the world for fire retarding capacity in consumer products.

One of the few available reports on BFRs in the southern California region by NOAA's National Status and Trends (NS&T) Program suggested that marine bivalves from the Southern California coast have among the highest levels of polybrominated diphenyl ethers (PBDEs) in the country, which are the most widely used BFR mixture in consumer products (Fig. 1). This was recently followed by a report of elevated levels of PBDEs in peregrine falcons frequenting the Los Angeles/Long Beach Harbor Complex, with levels among the highest ever reported in wildlife.

Like legacy organochlorines (e.g. DDT and PCBs), PBDEs accumulate in sediments because they are particle reactive and relatively stable in the environment. Recently, NOAA and SCCWRP have developed laboratory protocols for detecting environmentally relevant PBDE congeners in sediment samples. These protocols are subject to rigorous, performance-based QA/QC guidelines such as those instituted for the other organic analytes in the Bight program. Using these protocols, SCCWRP measured elevated levels of PBDEs, both in seafloor sediments and in liver from hornyhead turbot, near large POTW ocean outfalls in the SCB. However, only a very small number of sediment samples near large POTW ocean outfalls were collected. Thus, the extent and severity of PBDE contamination in SCB sediments remains unknown.

The goal of this project is to assess the magnitude and spatial extent of PBDE contamination in sediments of the SCB. The project will consist of two tasks:

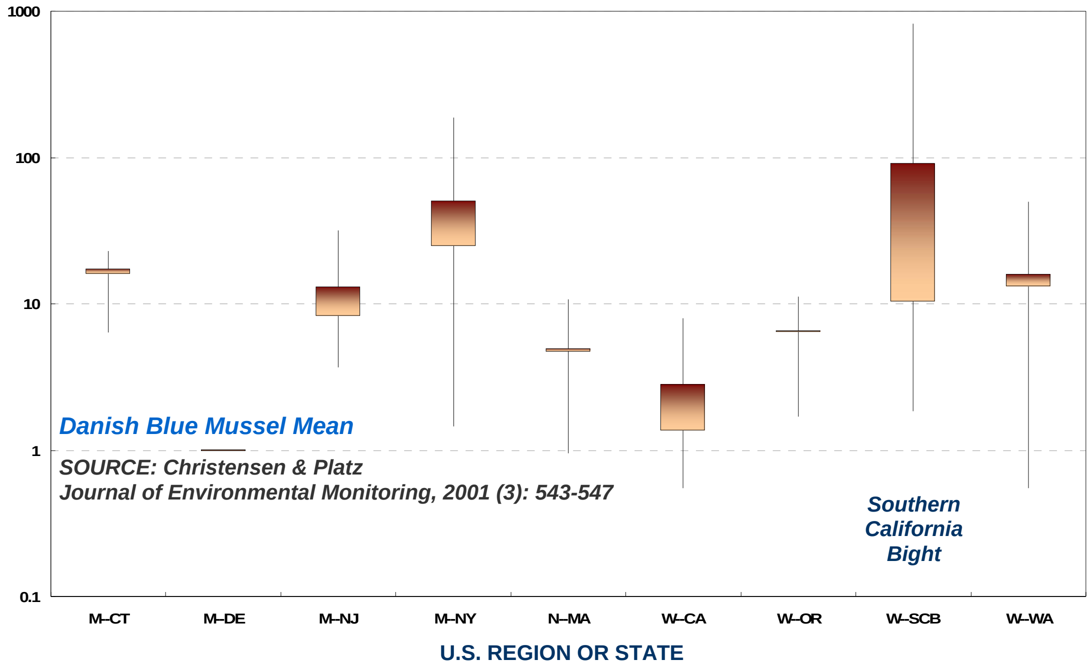

Fig. 1. Mean and range of polybrominated diphenyl ether concentrations (PBDEs) in bivalves collected by NOAA's National Status and Trends (NS&T) "Mussel Watch" Program. (courtesy of J. Christensen, NOAA/NOS/NCCOS/CCMA). The Southern California Bight has among the highest levels of PBDEs in the country.

Task 1. Sample sediments for PBDEs.
Surficial sediments will be collected from all 374 benthic sampling stations selected for the B08 effort. A separate aliquot of surface sediment will be stored and handled for PBDE analysis in a fashion similar to other trace organic compounds. These samples will then be shipped to NOAA/NOS/NCCOS for analysis.

Task 2. Laboratory analysis and reporting.
Research-grade laboratory techniques will be used to identify and quantify levels of 12 or more individual PBDE congeners. PBDE levels will be compared across B'08 geographical strata similar to that used for other trace contaminants. The results of this study will be prepared as stand alone article that can be incorporated as part of the B'08 Sediment Chemistry report.

SPECIAL STUDY 3

TITLE: Pharmaceuticals and personal care products (PPCPs) in Southern California coastal sediments

COLLABORATORS:

Tony Pait, NOAA/NOS/NCCOS/CCMA, Silver Spring, MD
Ed Furlong, USGS/NWQL, Denver, CO
Hee Gu Choi, Minkyu Choi, National Fisheries Research and Development Institute, Busan, Republic of Korea

The profound effect of pharmaceuticals and personal care products (PPCPs) on aquatic life was first documented over 20 years ago in freshwater rivers receiving treated wastewater. More recent studies have suggested that endocrine disruption in flatfish of the Los Angeles Margin may be enhanced near large publicly owned treatment works **(**POTW) outfalls. Initial efforts to determine likely sources and/or causative chemical agents in our region, however, have focused on regulated "legacy" contaminants that have been largely inconclusive. Because sampling and analysis of unregulated, emerging contaminants like PPCPs currently requires specialized equipment and substantial expertise, effort, and cost, little to no effort has been taken to measure these constituents in Southern California Bight (SCB) ecosystems.

Preliminary studies are beginning to examine the presence of PPCPs in the SCB. Thus far, PPCPs were measured in treated effluent and receiving waters associated with the largest POTWs in the SCB. However, the preliminary data also show that concentrations of detectable PPCPs appeared to differ among effluents. Furthermore, detectable, but low levels of PPCPs were found in receiving waters near these POTWs. This is not entirely surprising as treatment plant influent and unit processes vary and a very high degree of dilution is routinely achieved. In a parallel study, NOAA (our special study collaborator) has detected low levels (~parts per trillion or less) of PPCPs in Chesapeake Bay. Thus, it is becoming increasingly common to detect water soluble PPCPs in even highly treated effluent as well as in aqueous compartments of receiving water ecosystems.

Sediments serve as a repository for contaminants that are particle reactive and relatively stable in the environment. Recently, the USGS has developed protocols for detecting numerous PPCPs in sediment (Table 1). Only a very small number of sediment samples, taken near large POTW ocean outfalls, have been collected. Although only a few PPCPs were analyzed in these sediment samples, a handful of compounds such as carbamazepine (an anti-convulsant), diazepam (a tranquilizer) and triclosan (an anti-bacterial) were detected. Thus, characterizing a larger number of PPCPs in the SCB, especially those that persist at elevated levels in coastal sediments, appears warranted.

The goal of this special study is to address the following questions:

1. What is the occurrence and levels of PPCPs and other emerging contaminants in coastal shelf sediments impacted by large POTW ocean outfalls?

2. What is the occurrence and levels of PPCPs and other emerging contaminants in coastal embayment sediments impacted by urban runoff?
3. Do PPCPs co-occur with the presence of other wastewater markers?

This special study will consist of three tasks:

Task 1. Sample sediments for PPCPs.
Surficial sediments will be collected from 28 pre-selected stations representing coastal shelf and embayment habitats of the SCB. For the mid-shelf habitat (30-120 m depth), stations corresponding to the five largest POTW ocean discharges as well as geographically distributed "far-field" stations will be targeted. For coastal embayments, estuarine sites that receive substantial inputs of wastewater or urban runoff will be targeted. Sediment samples will be collected in collaboration with B'08 participants and shipped to the USGS National Water Quality Lab in Denver.

Task 2. Sample sediments and near-bottom water for markers of human waste

Surficial sediments and near-bottom water (within 2 m) will be sampled for a suite of microbial markers of human waste. These will include fecal indicator bacteria, human specific viruses, and other bacteria species found in human fecal waste (Table 2). These samples will be collected at the same sites as the PPCPs.

Task 3. Laboratory analysis and reporting.
Research-grade laboratory techniques will be used to identify and quantify levels of 20 or more individual PPCPs. PPCP levels will be compared between discharge and farfield sites. Comparisons will also be made between offshore and embayment sites. The microbial markers will be compared between nearfield and farfield sites as well their co-occurrence with the PPCPs. The results of this study will be prepared as stand alone article that can be incorporated as part of the B'08 Sediment Chemistry report.

Table 1. List of target PPCPs in sediments.

1,7-dimethylxanthine	diltiazem
acetaminophen	diphenhydramine
albuterol	erythromycin
azithromycin	fluoxetine
caffeine	miconazole
carbamazepine	ranitidine
cimetidine	sulfamethoxazole
codeine	thiabendazole
cotinine	trimethoprim
dehydronifedipine	warfarin

Table 2. Suite of microbial analyses to be performed

	Water	**Sediment**
Fecal Coliforms	**X**	**X**
E. coli	**X**	**X**
Enterococcus	**X**	**X**
F+ RNA Coliphage	**X**	**X**
Enterovirus	**X**	**X**
Norovirus	**X**	**X**
Methanobrevibacter smithii	**X**	**X**
Bacteroides sp.	**X**	**X**

SPECIAL STUDY 4

TITLE: Variability in Sediment Chemistry between grab and composite samples

COLLABORATORS: Toxicology and Chemistry Committee members

Sediment quality surveys traditionally collect sediment for both toxicology and chemistry analyses. Typically, multiple grabs are needed to obtain sufficient sediment for analysis. Often, monitoring programs composite or split samples in order to increase the comparability of the chemistry and toxicity data. An alternative approach, sequential sampling where separate grabs are used for chemistry and toxicology samples, is used in the Bight program. The sequential sampling approach reduces the potential for cross contamination between samples and assumes that any variability in sample composition among grab samples is insignificant. However, the magnitude of variability among the sequential grabs samples used in the Bight program has not been documented. If the variability is substantial, then it may confound the interpretation and integration of the data for the purposes of assessing sediment quality.

The goal of this special study is to examine the effects of sediment sample processing on sediment chemistry results and determines if the effects can influence the interpretation of the toxicity results. Two specific questions will be addressed:

4) Does variability between grab and composite samples influence the sediment chemistry data for separate grabs?
5) Does one sample processing methodology provide a better relationship between sediment chemistry and toxicity results?

The special study will consist of two tasks that mirror each of the above questions.

Task 1. Compare sediment chemistry between sample types.
Both sequential and composite sediment chemistry samples will be collected from 20 embayment Bight'08 stations across 9 water bodies. Stations will be selected by review of previous data to represent a range of sediment characteristics and toxicity. Sediment samples from each station will be processed for chemistry analysis by two distinct methods 1) a sediment chemistry grab will be taken specifically for chemical analysis and 2) a second chemistry sample will be obtained from multiple composited grabs used for toxicity analysis. The concentration of chlorinated pesticides, PCBs, and PAHs will be measured in each sample.

Task 2. Compare relationship between sediment chemistry and toxicity for each type of sampling method.
The results from the chemistry analyses will be correlated to the sediment toxicity results to see if one processing method (i.e., grab or composite) provides a better prediction of effects. The results will be summarized in a report that will be included as an appendix to the Toxicology or Chemistry Technical Report. The report will also make a recommendation as to the preferred method for future Bight surveys.

SPECIAL STUDY 5

TITLE: Sediment toxicity identification evaluations in southern California embayments

COLLABORATORS: Dominic Gregorio, State Water Resources Control Board

Sediment quality surveys have historically shown that embayments have the highest contaminant concentrations and greatest incidence of sediment toxicity. It is difficult to use these results directly to select management actions for improving sediment quality because chemistry and sediment toxicity data by themselves do not identify the specific chemicals responsible for biological impacts. In the 2003 Bight survey, sediment toxicity identification evaluations (TIEs) were conducted on sediment from two estuaries in Los Angeles County. TIEs are a series of chemical manipulations of a toxic sample that alter the biological availability of specific contaminants. In the Bight'03 survey, TIE analyses effectively narrowed the toxic stressors to organic contaminants, possibly pyrethroid pesticides. However, the TIE results were limited and it is not known whether the patterns found in 2003 are representative of other embayments in southern California.

The goal of this special study is to characterize the likely toxicants in sediments from southern California embayments using TIE methods. The specific questions to be addressed include:

1) What contaminant(s) are likely responsible for amphipod toxicity in embayments?
2) Do the toxicity characteristics of whole sediment and pore water differ?

A particular focus will be placed on determining if pyrethroid pesticides play a role in the toxicity observed. In addition, this special study will help to standardize TIE methods among the laboratories participating in the survey.

The special study will consist of two tasks.

Task 1. Select stations for TIE analysis

The TIE stations will be selected based on the amphipod toxicity test results. Approximately 15 stations located in embayments will be selected for analysis based on two criteria; magnitude of toxicity and location. Priority will be given to stations having >50% amphipod mortality and located in a diversity of water bodies. Approximately 4-8L of extra sediment for TIE analysis will be collected from each station selected.

Task 2. Conduct TIE analyses

TIE methods will be applied to both whole sediment and pore water for characterizing the toxicity in each matrix. All tests will use the amphipod *E. estuarius*. The whole sediment TIE methods will include: addition of carbon, addition of cation exchange resin, addition of piperonyl butoxide, addition of carboxyl esterase, and temperature reduction. Pore water will be extracted using centrifugation and treated with the following TIE methods: EDTA addition, C-18 solid phase extraction, addition of piperonyl butoxide, addition of carboxyl esterase, and temperature reduction. Changes in the toxicity of the sample following each type of treatment will indicate whether the toxicity has characteristics of a nonpolar organic, trace metal, or pyrethroid pesticide. The TIE results will be summarized in an article to be incorporated into the Toxicology Technical Report.

SPECIAL STUDY 6

TITLE: Evaluation of an AVS-SEM Partitioning Model to Predict the Contribution of Metal Contamination on Sediment Toxicity

COLLABORATORS: Copper Development Association

Sediment quality surveys have historically shown that embayments have the highest contaminant concentrations and measures of biological effects. One focus of the Bight'08 program is to better characterize chemical effects in bays, estuaries and lagoons. Part of the challenge in interpreting sediment quality data is the difficulty determining the cause of sediment toxicity from sediment chemistry analysis alone. One reason for this difficulty is that total sediment chemistry does not predict the bioavailability of contaminants to benthic organisms. Models that can predict toxicity associated with specific sediment constituents are needed to assist decision makers in determining the appropriate management actions in impaired water bodies. The measurement of acid volatile sulfides and the concentration of simultaneously extracted metals (AVS-SEM) is a tool developed by the USEPA to predict the bioavailability and toxicity of metals in sediments by estimating the capacity of sediment sulfides to tightly bind specific metals. Few AVS-SEM data are available for southern California sediments and the ability of this tool to help predict sediment toxicity is uncertain.

The goal of this special study is to increase the AVS-SEM data for southern California. This will enable a more thorough evaluation of this methodology to reduce the uncertainty of associating toxicity with specific sediment constituents. Two specific questions will be addressed:

3) What is the spatial distribution of AVS concentrations throughout Bight embayments?
4) What is the relative contribution of AVS in mitigating biological effects of metal contaminated sediments?

The special study will consist of two tasks.

Task 1. Sediment collection and analysis.
Sediment samples from 180 sites distributed among ports, bays, estuaries, and lagoons throughout Southern California will be collected. The sediment samples will be extracted in the laboratory using a weak acid solution and the concentration of liberated sulfide and trace metals will be measured.

Task 2. Compare the relationship of AVS-SEM concentrations to sediment toxicity.
The AVS and SEM data will be used to determine whether the concentration of sediment trace metals exceeds the sulfide binding capacity. The potential for sediment toxicity will be estimated using an USEPA partitioning model. These predictions will be compared to the measured toxicity at each site in order to determine the efficacy of the model. The results will also be compared to the results of sediment TIE analyses conducted at a subset of the embayment sites (see Special Study 5). The results of this study will be summarized in an article that will be incorporated into the Toxicology Technical Report.

SPECIAL STUDY 7

TITLE: Assessment of copper speciation and toxicity in southern California marinas

COLLABORATORS: Jim Moffett, University of Southern California

A recent statewide study conducted by the California Department of Pesticide Regulation (DPR) determined that in salt and brackish water areas, 15 of 17 marinas sampled exceeded EPA chronic water quality standards for copper (4.9×10^{-8} M). Ten of these 15 marinas also exceeded acute standards (7.6×10^{-8} M) . The main source of copper in these areas is from boat antifouling paints. No alternatives to copper have been identified that do not have their own potential side effects. This led the DPR to announce late last year that it would pursue re-evaluation of all antifouling paints based on these findings.

Although there was widespread copper contamination, toxicity to *Mytilus* larvae was present at fewer sites suggesting that free copper ions (Cu^{2+}) and resulting toxicity may be mitigated by complexation with organic matter in some marinas. As a result, a case could be made for the adoption of site specific objectives, as has happened in the NY/NJ Harbor and proposed for Calleguas Creek, which would have significant implications for the cost and extent of copper mitigation efforts.

The goal of this special study is to assess the molecular understanding of copper behavior in marinas by improving the precision and accuracy of quantitative approaches currently used to measure dissolved copper levels. This information can be used DPR for its re-registration program and by the RWQCBs for making decisions about water quality impacts in marinas that may lead to regulatory actions such as TMDLs. Specific questions to be addressed are:

1) How does the concentration of dissolved copper, and the concentration of free Cu^{2+}, vary in these marinas, and what are the principal factors that account for these differences?
2) How do levels of dissolved copper correlate with *Mytilus* toxicity data?

The special study will consist of three tasks that address each of the above questions.

Task 1. **Characterize the chemical speciation of copper**.
The chemical speciation of copper will be characterized in two representative southern California marinas with similar characteristics of size, boat density and flushing characteristics (i.e. water residence times), and characterize. The concentration and binding constants of copper ligands in each system will be measured and free Cu^{2+}, the toxic form, will be calculated.

Task 2. **Compare toxicity data with free Cu2+ concentrations.**
The free Cu^{2+} concentration of water samples from *Mytilus* toxicity tests of Bight'08 samples located in the marina study sites will be measured and compared to the toxicity results. These results will also be compared to dose-response information for *Mytilus* embryos for free Cu^{2+} already derived (Moffett, unpublished) and existing water quality standards. These data will establish whether a case should be made for site-specific water quality objectives and help us to inter-compare results from various toxicity testing tools including the sediment TIEs (see Special

Study 5). The results will be presented in an article to be incorporated into the Toxicology Technical Report.

SPECIAL STUDY 8

TITLE: Endocrine disruption indicators in fish from reference areas

COLLABORATORS: Kevin Kelley, Environmental Endocrinology Laboratory, California State University at Long Beach

Southern California coastal waters receive inputs of contaminants every day from multiple sources that include treated municipal wastewater, urban runoff, and agricultural drainage. These discharges contain hormones, pharmaceuticals, personal care products, and industrial compounds not currently regulated or monitored; some of which are known endocrine disruptors of fish and other aquatic organisms. Previous studies have detected several indicators of endocrine disruption in hornyhead turbot, including production of egg yolk proteins and relatively high estrogen concentrations in males, and depressed cortisol concentrations. Some of these responses are widespread, being present in fish from areas near wastewater discharges and also from farfield locations. The interpretation of the biological significance of these findings is difficult because of limited data that describe the baseline condition of hornyhead turbot from areas not exposed to environmental contaminants. Without baseline data on these indicators, we cannot determine whether the responses are indicative of wide-ranging adverse effects or just represent the unique characteristics of hornyhead turbot. The large spatial coverage of the Bight'08 regional survey provides an opportunity to obtain fish samples from areas distant from contaminant inputs and thus help to clarify our understanding of the baseline endocrine condition in hornyhead turbot.

The objective of this study is to determine the hormone status of hornyhead turbot collected from presumed reference areas (e.g., far from municipal wastewater discharges). The specific questions to be addressed in the special study include:

1) What is the range of hormone and vitellogenin concentration in fish from reference areas of the SCB?
2) Are there differences in endocrine status of fish collected from different reference areas of the SCB?

The special study will consist of two tasks.

Task 1. Fish collection from reference areas.
Hornyhead turbot will be collected from two reference areas; the northern part of the SCB near Santa Barbara and the central part of the SCB near Dana Point. Trawl data from previous Bight programs indicate that hornyhead turbot are present at offshore locations in these two areas that are distant from large municipal wastewater outfalls and expected to have relatively low concentrations of contaminants of emerging concern. Sampling teams will accompany trawl personnel on visits to stations in the two reference areas and collect blood and tissue samples from adult (> 12 cm) hornyhead turbot. Between 15 and 30 hornyhead turbot will be sampled from each area, provided sufficient fish are captured. Blood plasma, liver, and gonad tissue samples from each fish will be removed on board the ship and frozen on dry ice or preserved in formalin for transport and storage.

Task 2. Protein and hormone analyses.
The plasma samples from each fish will be analyzed for the concentration of three indicators of endocrine disruption: vitellogenin, estradiol (i.e., estrogen), and cortisol. The estradiol and cortisol analyses will be conducted using RIA (radioimmunoassay) by the Environmental Endocrinology Laboratory at California State University, Long Beach. Plasma vitellogenin will be measured at SCCWRP using ELISA. The liver and gonad samples will be archived at SCCWRP for possible future analysis, depending on funding and the results of the plasma analyses.

The results of this study will be summarized in an article and incorporated into the Trawl Technical Report. The hormone and vitellogenin results will be compared to previous hornyhead turbot data from sites near large wastewater outfalls and also Dana Pt. Statistical analyses will be conducted to determine whether the results for fish from the Bight'08 reference areas differ from fish from the other sites. The presence of temporal differences in hormones between Dana Pt. Fish collected in different years will also be investigated. These data will provide valuable and hard to obtain data on the hormone status of fish from areas that have not been previously sampled, which will improve our perspective on the significance of existing endocrine disruption data near discharges.

SPECIAL STUDY 9

TITLE: Foraminifera as indicators of ecosystem health in the Bight

COLLABORATOR: Mary McGann, U.S. Geological Survey, Menlo Park, CA

The southern California Bight was the site of the first studies comparing the distribution of foraminifera in pristine and anthropogenically-impacted marine environments. Starting in the late 1950s and early 1960s, benthic sampling programs financed by the U.S. Public Health Service Division of Water Supply and Pollution Control and the California State Water Pollution Control Board were undertaken on the shelf area from Point Conception to the United States-Mexico border. The investigations emphasized localities near municipal sludge and watewater discharge sites, including the Santa Barbara, Hyperion, Whites Point, Orange County, and Laguna Beach outfalls. These studies, and numerous others conducted later in bays, harbors and coastal margins around the world, demonstrate that the distribution of foraminifera is affected by anthropogenic contamination, including increased heavy metal loading, organic enrichment of the sediments from domestic sewage, paper mills, fertilizer production, and aquaculture, and byproducts of chemical, coal, and fuel ash production. Foraminiferal responses to these contaminants are wide-ranging and temporally easy to track. In the presence of increased dissolved organic matter, the abundance and diversity of foraminifera increase. In areas that are moderately polluted, test deformation, modifications of the assemblage, and disturbance of life activities may result. In the most highly impacted regions, local extinctions or barren zones are present. Because these tiny organisms are abundant and easily collected, and their secreted shells are affected by their environment, they are ideal organisms for monitoring the effect of anthropogenic input on the ecosystem.

A half-century has passed since these landmark studies were undertaken off southern California and only two sites have since been reexamined to determine how improved municipal wastewater treatment has affected the local foraminiferal assemblages. Variations in the temporal distribution patterns from 1957 to 1998 suggest that the benthic microfaunal communities have been greatly affected by the presence of contaminated sediment. Six species were most impacted: *Trochammina pacifica*, *Bulimina denudata*, *Eggerella advena*, *Buliminella elegantissima*, *Nonionella stella*, and *Nonionella basispinata*. The pollution-tolerant species *Trochammina pacifica* and *Bulimina denudata* dominated the outfall regions in the mid-century, but declined in abundance in the 1990s after sewage treatment and sludge disposal activities improved. Over the same time period, the abundance of *Eggerella advena*, a pioneer colonizer of formerly impacted waste-discharge sites tolerant of most trace metal and organic contaminants, increased dramatically on the shelf. Whereas *Buliminella elegantissima*, a nitrogen-favoring taxon, dominated the nearshore regions except at the pristine sites. In contrast, the contaminant-sensitive species *Nonionella stella* and *Nonionella basispinata* dominated the shelf assemblages in pristine to low-impacted areas in the late 1950s and early 1960s, but were rare to absent near the outfalls, even after remediation efforts were put into effect. Although most other species patterns, as well as the amphipod survival and sea urchin fertilization tests, show that the enhanced sewage treatment programs improved sediment conditions, the inability of *Nonionella stella* and *Nonionella basispinata* to re-inhabit formerly colonized areas suggests that not all faunal trends have returned to pre- or early-outfall levels even with remediation. It is unclear whether the inability of these species to colonize formerly occupied areas is due to persistent degradation in sediment quality from past discharges, sensitivity to present discharges, or evidence of a competitive advantage favoring the now-dominant taxa, such as *Eggerella advena*. Obviously, there is a need to reexamine the affects of remediation on the foraminiferal faunas at the other outfalls in the Bight to determine which species are now abundant and whether *Nonionella stella* and *Nonionella basispinata* have returned to previously occupied sites.

The goal of this special study is to investigate the impact of contaminated sediment on the foraminiferal communities in the southern California Bight and to assist in characterizing the health of its ecosystem. The special study is comprised of two tasks:

Task 1. Microfaunal distribution in the bays, ports, marinas, estuaries, and lagoons.
We will generate a dataset of the spatial distribution of foraminifera in selected areas of the Bight. We will produce a report that summarizes the relationships between the foraminiferal data, grain size, and sediment contaminants. This report will be incorporated into the Benthic Infaunal Technical Report.

Task 2. Comparison of the abundance of *Bulimina denudata* and sediment toxicity.

We will compare the abundance of the foraminifer *Bulimina denudata* with the standard measures of sediment toxicity (amphipod survival and sea urchin fertilization) obtained from the same localities of the Bight '08 study to see if there is a correlation between these parameters. We will write a report describing this relationship. This report will be incorporated into the Benthic Infaunal Technical Report.

SPECIAL STUDY 10

TITLE: Antifouling compound Irgarol 1051 and its metabolite M1 in surface water and sediments of California marinas

COLLABORATORS: Yelena Sapozhnikova, NOAA, Estuaries and Land Use Division, Charleston, SC

Irgarol 1051 is a common antifouling booster biocide that is used worldwide in copper-based paints. It is a triazine-based herbicide (2-methylthio-4-*tert*-butylamino-6-cyclopropylamino-*s*-triazine). Irgarol degrades in seawater with half-life of about 100 days, producing its major degradation product 2-methylthio-4-tert-butylamino-6-amino-s-triazine (also known as M1). Irgarol has relatively high octanol/water partition coefficient log K_{ow} = 3.95, suggesting high tendency to accumulate in sediments. As a result of Irgarol's wide use, concentrations have been reported in water (up to 4,200 ng/L) and sediments (up to 220 ng/g) worldwide.

In a previous study of Irgarol in 2005, concentrations reached up to 304 ng/L in San Diego region marinas, some of the highest concentrations of Irgarol measured on the west coast of the United States at the time. In a follow up study of marinas throughout California, Irgarol was detected in all marina samples, representing 100% frequency of detection and indicating widespread distribution of Irgarol in marinas from a wide spatial area. The maximum Irgarol concentration detected in California marinas in 2006 (712 ng/L) was five times greater than the Irgarol concentration suggested as the plant toxicity benchmark (136 ng/L). These measurements are based on surface water concentrations only. To our knowledge, there are no values for sediment concentrations of Irgarol from the west coast of the USA.

The purpose of this special study is to measure Irgarol and its metabolite concentrations in California marinas water and sediments. The goal will be to assess Irgarol and M1 frequency of occurrence in both water and sediments, range of concentrations, and comparison to risk thresholds and biological effects from the other indicator measurements collected as part of the Bight'08 study. This will be accomplished in two tasks.

Task 1. Sample collection. A total of 44 samples of surface water and surficial sediments will be collected from marinas during the Bight'08 survey. The samples will be stored to minimize degradation and shipped to the NOAA laboratory in Charleston, SC

Task 2. Laboratory analysis and reporting. The samples will be analyzed for Irgarol and M1 using research-grade techniques. Solid-Phase Extraction will be used for water samples and Accelerated Solvent Extraction will be used for extracting sediments. Samples will be quantified using Liquid Chromatography Tandem Mass Spectrometry (LC-MS-MS) Method detection limits of both analytes approach 1 ng/L for water samples and 1 ng/g for sediments. Results will be written into an article for publication and included in the Bight'08 Sediment Chemistry Technical Report.