California MLPA Master Plan Science Advisory Team
Draft Recommendations for Considering Water Quality and Marine Protected Areas in the MLPA South Coast Study Region

Draft revised February 9, 2009

The purpose of this document is to provide guidance and additional information to assist the MLPA South Coast Regional Stakeholder Group (SCRSG) in developing alternative marine protected area (MPA) proposals. Also provided are proposed concepts for an informative evaluation of MPA proposals with reference to water quality issues. Lastly, this document provides the MLPA Master Plan Science Advisory Team (SAT) Water Quality Work Group's recommendations for post-MPA implementation strategies to protect and restore water quality. Thus this document is divided into four sections:

1. Background
2. Stakeholder consideration of water quality in the MLPA South Coast Study Region (SCSR)
3. Using water quality maps and figures during MPA proposal development
4. Potential post-MPA designation implementation strategies to protect and restore water quality

1. Background

The Marine Life Protection Act (MLPA; Stats. 1999, Chapter 1015) mentions water quality concerns in several places [Section 2851(c), Section 2852(d), Section 2853(b)(1), Section 2855 (b)(3), Section 2857(b)(2)], but does not offer any guidance or direction on how to treat water quality issues when siting MPAs.

The Marine Managed Areas Improvement Act (MMAIA; Stats. 2000, Chapter 385), which is complementary to the MLPA, does address water quality concerns with the establishment of state water quality protection areas (SWQPAs). SWQPAs include areas of special biological significance (ASBS). SWQPAs, inclusive of ASBSs, must be designated by the State Water Resources Control Board.

2. Stakeholder Consideration of Water Quality in the MLPA South Coast Study Region

Water quality[1] is a concern in the MLPA SCSR and should be considered during the MPA planning and design process. Degraded water quality can threaten organisms and could be a barrier to the revitalization of ecosystems in areas set aside for protection.

The MLPA SCRSG should consider avoiding locating proposed MPAs in areas of poor or threatened water quality, such as at major cooling water intake sites for power plants, municipal sewage or industrial outfalls, and in areas that are significantly impacted by a variety of pollutants from large industrial or developed watersheds in the study region. Of foremost concern are the larger of these cooling water intakes and discharge sites. Underlying

[1] The term "water quality" as mentioned in this document, will stand for the condition of the water column when referenced as such, and the condition of the sediment, when referenced as such. Therefore, the term water quality, in this document, is synonymous for both sediment quality and water column quality.

oceanographic patterns and other abiotic factors should also be considered. On the other hand, co-locating MPAs with ASBSs may provide a more complete package of protection. In any case, water quality should not be used as a final determinant in the evaluation of MPA proposals, but rather considered to inform the process and siting of MPAs. Ultimately MPAs should be proposed and established based on the requirements of the MLPA. Further protection from water quality threats, or restoration of water quality to meet standards, should be targets to be accomplished after MPA implementation using the appropriate mechanisms.

Additional information has been compiled as a set of maps and tables to assist the SCRSG in identifying areas with water quality concerns and the locations of existing ASBSs. The following section provides descriptions and guidance on how to interpret these data.

3. Using Water Quality Maps and Figures during MPA Proposal Development

There are two sets of water quality maps that will be available to help inform the SCRSG of water quality issues during the development of MPA proposals. The first set of maps (maps 1 and 2) is labeled “Areas of Water Quality Concerns” and the second set (map 3) is labeled “Water Quality Areas of Opportunity”. These two sets of maps consist of data layers that will be described in detail below. The SCRSG should view the maps for areas of water quality concerns and exercise caution when proposing MPAs in these designated areas. Data from these maps will be available on MarineMap (www.marinemap.org/mlap).

The water quality issues on these maps have been prioritized in order of sites that have major ecological effects to sites with relatively minor ecological effects; these are listed here in order, with the first having the greatest effect on MPA implementation:

- ***Intakes and discharges from power generating facilities*** are the greatest threat because they operate year round and there is virtually complete mortality for any larvae entrained through the cooling water intake system. Impingement on intake screens is also of concern to larger organisms such as fish. Power plants also have cooling water discharges, and in some instances these discharges are in the vicinity of the plant intakes. Where this occurs the effects of the discharges would be much less compared with the effects of the intakes. There are instances where the discharges are located in separate water bodies. In such cases, the cooling water discharges affect the surrounding ecosystem, but not nearly as much as the intakes. The discharge effects include thermal pollution and sedimentation caused by turbidity plumes from the discharges. Of all the water quality threats, the power plant intakes pose the greatest threat to the nearby ecosystem and MPAs placed where power plant intakes occur within their boundaries have a large chance of not fulfilling the goals of the MLPA.

- ***Storm drain effluents*** are known to be toxic to larvae, but they are generally of lesser concern than power plants because their plume effect extends beyond the immediate shoreline only about a dozen or so days per year, following big rainstorms. Moreover, these storms primarily occur during winter, which is not the prime spawning season for most fish species, and the plumes are not much of a threat to older life stages that have sufficient mobility to avoid them.

- ***Wastewater effluents*** are of concern because sediments in their immediate vicinity sometimes have elevated contaminant concentrations relative to background. However, they are of less concern than power plant intakes and discharges and storm drain effluents because treated wastewater effluents, even before dilution in the receiving environment, are rarely toxic to biota. Even the sediments near the outfall are rarely toxic, although there is evidence of sublethal effects (e.g. such as those mediated by endocrine disruptors) to some flatfish in the immediate vicinity of the discharge.

In examining the data sets provided to the SCRSG, consideration should be weighted towards those features known to have harmful effects on marine life and not those that strictly affect human interaction with the impaired water body. The set of maps labeled "water quality areas of opportunity" provide the locations of ASBSs where consideration may be given to co-locating MPAs with ASBSs in order to maximize the water quality protections built into the designation of ASBSs.

This document also includes some data sets describing the mussel watch data and a brief summary of hypoxia, both of which will be described below.

Descriptions of Layers on the "Areas of Water Quality Concerns" Map

Power Plant Intake and Discharge Sites

There are 12 large coastal power plants (at least 50 megawatts of generating capacity) in the study region that use a "once-through" cooling system that draws water from a nearby open water source such as a bay, estuary, or ocean. Impingement occurs when organisms are trapped against or within components of the cooling system, such as screens. Impingement usually affects larger organisms such as fish that are trapped within or against the cooling water system structures and either die of starvation or exhaustion[2]. Entrainment occurs when organisms are drawn through the cooling system. Entrainment kills smaller organisms in early life stages by exposing them to increased water temperatures beyond thermal tolerances, mechanical damage, or toxic stress and has the most significant effects on marine systems, particularly on the availability of larvae for downstream sites. These intake systems can impinge and entrain marine organisms and larvae over a surprisingly large area, resulting in injury and death to scores of marine organisms. Thus, MPAs placed farther away from major cooling water intakes will have fewer deleterious impingement and entrainment effects on marine biota.

Power plants also discharge cooling water, and although the discharge effects on the surrounding ecosystem are not as great as the intakes, thermal pollution and increased turbidity do occur near these outfalls. This can impact marine organisms that are either

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[2] See the California Energy Commission's webpage for more information at www.energy.ca.gov.

sensitive to temperature fluctuations or organisms, such as kelp, that are impacted by decreased light attenuation caused by increases in water column turbidity. The cooling water discharge data on the map will fall under the waste water discharge category and will have an impact zone of 0.5 miles drawn around each site, which is the same radius that has been adopted for the industrial and municipal wastewater discharge sites.

Table 1 lists each of the 12 power plant sites according to the number of larvae entrained. Both scale and location are important factors when considering the impacts from larval entrainment. For instance, the San Onofre Nuclear Generating Station (SONGS) draws in many more larvae than the other power plants, while the Ormond Beach Generating Station draws in the least – less than 1% of SONGS (Table 1).

The location of each power plant is displayed in maps 1a, 2a, and 3a, together with a shaded area that indicates the extent of the entrainment impact. The color indicates the total number of larvae entrained (obtained from 316b reports) and the spatial extent of the box indicates a volume of water equivalent to ten days of cooling water. This area does not define a zone of impact, but rather provides a visual sense of the scale over which larval mortality due to entrainment may be of concern, and the relative sizes of this area due to different pumping rates for different plants. This area calculation is based on several assumptions, including (i) that alongshore extent is 5-times cross-shore extent, (ii) bottom depth slopes linearly to about 10 meters at the outer edge of this entrained volume, and (iii) the entrainment area appears on both sides of the intake as currents may run in one direction or the other. Where the intake is in an enclosed bay, this area extends beyond the bay when the bay holds less volume than that pumped in a 10-day period (e.g., Alamitos Bay), or is confined to the bay where the bay is large enough (e.g., San Diego Bay). This is a simplified approach and a more detailed assessment should be developed for any specific site that may interact with nearby MPA's.

Table 1. Power plant entrainment and impingement estimates of mortality for marine organisms at 12 power plant in the study region.

Facility	Entrainment (Larvae-Per-Year)	Impingement (Total Annual Biomass Estimate in lbs)	Intake Location
San Onofre Nuclear Generating Station, Units 2, & 3	6,230,819,601	32,802	Coastal
Encina Power Plant	3,161,960,103	3,498	Enclosed Bay
Alamitos Generating Station, Units 1, 2, 3, 4, 5 and 6	2,954,339,708	2,249	Enclosed Bay
South Bay Power Plant	1,667,044,144	751	Enclosed Bay
Haynes Generating Station	1,159,409,807	3,112	Enclosed Bay
AES Redondo Beach Generating Station 5, 6, 7 and 8	373,757,257	967	Coastal
Scattergood Generating Station	315,565,914	13,285	Coastal
El Segundo Generating Station 1, 2, 3 and 4	238,676,079	11,304	Coastal
Ocean Vista Power Station at Mandalay B	129,172,964	1,313	Enclosed Bay

Facility	Entrainment (Larvae-Per-Year)	Impingement (Total Annual Biomass Estimate in lbs)	Intake Location
AES Huntington Beach	104,316,376	2,559	Coastal
Harbor Generating Station	85,429,045	390	Enclosed Bay
Ormond Beach Generating Station	32,126,547	N/A	Coastal

Data Source[3] contracted by the California State Water Resources Control Board.

Stormwater Discharge Sites

Another point source of contaminants within the study region is storm water, with untreated stormwater being discharged from numerous storm drains during wet weather (winter). River and stream systems throughout southern California have been altered and can be major conduits for pollutants being transported to the ocean. For example, in the City of Los Angeles, there are 60 storm drains that release approximately 100 million gallons of untreated water each day into Santa Monica and San Pedro Bays[4]. Throughout the rest of the study region, there are numerous storm drain sites ranging from large sites such as rivers and creeks to smaller engineered channels. As described in Bay et al. (2003) “Stormwater discharge has the potential to impair the beneficial uses of the southern California’s coastal waters through (1) contamination of recreational waters or seafood with disease-causing microbes, (2) aesthetic degradation from trash, odors, and reduced water clarity, and (3) ecosystem degradation from contaminants or other stormwater constituents”[5]. The third of these impacts most directly pertains to the MLPA.

Due to the number of storm water discharge sites in the SCSR, the SAT recommends the SCRSG focus on the largest stormwater sites by discharge volume per year (see Table 2 for a list of the 19 largest runoff sites – all rivers and creeks). Without representing differences in pollutant loading, attention is given to the size of the runoff, which is represented on maps 1a, 2a, and 3a. These estimates of the relative extent of possible toxic impact is based on a study[4] performed by Bay et al. (2003), which found that the toxicity zone in the stormwater plume from Ballona Creek had an alongshore affect of approximately one mile up coast and one mile down coast, with an offshore extent of close to 0.75 miles. Assuming similar loading of stormwaters, similar linear bottom slopes, and that the relative volume of stormwater plumes scales with the annual runoff volume (Table 2), one can increase or decrease these Ballona-derived lengths by the cubic root of the volume ratio (as volume is related to length cubed). This provides a rough scale of the possible extent of stormwater impact for each of these

[3] Foster, M., Steinbeck, J. 2008. Compilation of California coastal power plant entrainment and impingement estimates for California State Water Resources Control Board staff draft issue paper on once-through cooling. California State Water Resources Control Board.

[4] City of Los Angeles. 2008b. About the Los Angeles Storm Drain System http://www.lacity.org/SAN/wpd/Siteorg/general/lastrmdrn.htm (accessed 08/1/08).

[5] Bay, SM, Jones, BH, Schiff, KC, Washburn, L. 2003. Water quality impacts of storm water discharges to Santa Monica Bay. Marine Environmental Research 56:205-223.

major stormwater sites. Again, this is a simplified approach and a more detailed assessment should be developed for any specific site that may interact with nearby MPA's.

Table 2. Top 19 stormwater drainage points by volume (gallons per year)

River/Stream Discharge Sites	Volume (10^9 Gallons Per-Year)
Los Angeles River	35
Santa Clara River	29
Santa Ana River	17
San Gabriel River	14
Calleguas Creek	13
San Luis Rey River	11
Santa Margarita River	10
Dominguez Channel	9
Ballona Creek	9
San Diego River	9
Penasquitos River	7
Tijuana River	6
Ventura River	6
Mission Viejo Watershed	4
Escondido Creek	3
Pueblo San Diego Watershed	3
Otay River/Watershed	3
San Dieguito River/Watershed	2
Oxnard Plain Watershed	2
Buenaventura Watershed	1

Source: Summarized by SCCWRP in 2008 from original data source[6]. Note: The areas above dams that control more that 20 square miles are removed. Therefore, areas in upper watersheds above dams are removed from contributing volume.

Industrial and Municipal Wastewater Discharge Sites

There are specific locations (point sources) where contaminants are discharged into coastal waters; these are generally regulated by state or federal agencies. The origin of these point sources include municipal wastewater treatment and disposal systems, desalination plants, power plant discharges, aquaculture sites, and research marine laboratories. There are 18 publicly owned treatment works plants, three desalination plants, 12 "once-through" cooling power plants, and six other permitted pollution discharge sites which include; aquaculture wastewater, marine lab waste seawater, refinery wastewater and treated sanitary waste from oil platforms. Other than the power plant discharges, of these point sources, only the municipal

[6] Ackerman, D. and Schiff, K. 2003. Modeling storm water mass emissions to the Southern California Bight. Journal of Environmental Engineering 129 (4): 308-317.

wastewater sites are considered to have the greatest sustained effects on the receiving aquatic system.

The point source discharge sites have been broken out by major, intermediate and minor impact ratings. The major waste discharges include the largest treated sanitary wastewater discharges (Los Angeles City, Los Angeles County, Orange County and San Diego/Point. Loma), the Terminal Island treated sanitary wastewater discharge into Los Angeles Harbor, the International Wastewater Plant discharge near the border (primary treatment only) and the SONGS discharge (known to have ecological effects on kelp). Intermediate ratings were given to other power plant discharges, medium volume wastewater plants and one small volume wastewater treatment outfall that is only primary treated and near shore (Goleta). The point sources with a minor pollution rating include desalination plants and the other permitted discharge points mentioned above.

Point source sites with a major pollution rating deserve more attention and have a larger effect on the surrounding environment. This "zone of impact" is represented on maps 1a, 2a, 3a, and 4a as 0.5 mile buffer area. Numerous parameters influence the extent of impacts from these point source pollutants, including oceanographic conditions, output flow, and the concentration of pollutant when dispersed at the source. Considering these parameters the SAT is designating a 0.5 mile zone as a typical or average extent of impacted area. It is important to note that this 0.5 mile area represents the SAT's best professional judgment and has been subjectively deduced from available data[7]. Thus, this 0.5 mile area should be considered as a conservative estimate of the zone of major impact. The actual impacts at any discharge point could be larger or smaller.

Sediment Contamination Sample Sites

Sediment contamination sites have been mapped to provide the working groups with more information. Sediment contamination data are helpful in understanding the health of the benthic environment. Anthropogenic contaminants such as heavy metals and persistent organic pollutants (POPs) can have negative affects on marine species. For example POPs, such as Dichloro-Diphenyl-Trichloroethane *(*DDT) and polychlorinated biphenyls (PCBs), become introduced into the marine environment, settle into the sediment and bioaccumulate through the food web, beginning with the benthic organisms[8]. These compounds have toxic effects on animal reproduction, immunological functions, and development[9]. Not only do the pollutants pose a threat to the marine organisms, after being integrated into the food web, they may pose a threat to humans as carcinogens or mutagens.

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[7] City of San Diego Annual Receiving Waters Monitoring Report for the Point Loma Ocean Outfall – 2007.

[8] Van der Oost, R., Beyeer, J., Vermeulen, N.P.E. 2003. Fish Bioaccumulation and biomarkers in environmental risk assessment: a review. *Environmental Toxicology and Pharmacology* 13:2 57-149.

[9] Muir D, Braune B, DeMarch B, Norstrom R, Wagemann R, Lockhart L, et al. 1999. Spatial and temporal trends and effects of contaminants in the Canadian Arctic marine ecosystem: a review. *Sci Total Environ* 230 (1-3):83-144.

One local example is off White Point on the Palos Verdes Shelf where a manufacturing plant in Torrance, California, discharged DDT into the Los Angeles County Sanitation Districts' wastewater collection system for nearly 30 years[10]. Although discharge of DDT was halted in the early 1970's, the lingering affects of this contamination remain and DDT is still a major contributor to many fish contamination zones around Los Angeles and Long Beach harbors. This site is on the EPA's Superfund list of most contaminated sites in the United States. A separate map of this site has been provided for reference (Figure 1).

Sediment samples and their contaminant levels are shown on maps 1b, 2b, 3b and 4b for both the coastal ocean areas and the bays and estuaries. Coastal ocean sites use a benthic response index (BRI), which determines the level of sediment contamination on the benthic community. Table 3 describes the BRI used in the data and presented in the maps.

In bays and estuaries, a more comprehensive approach is to use three lines of evidence to develop sediment quality objectives. The three lines of evidence include chemistry, toxicity, and the benthic response index. These data determine the degree to which sites are impacted and range from no impact to highly impacted[11].

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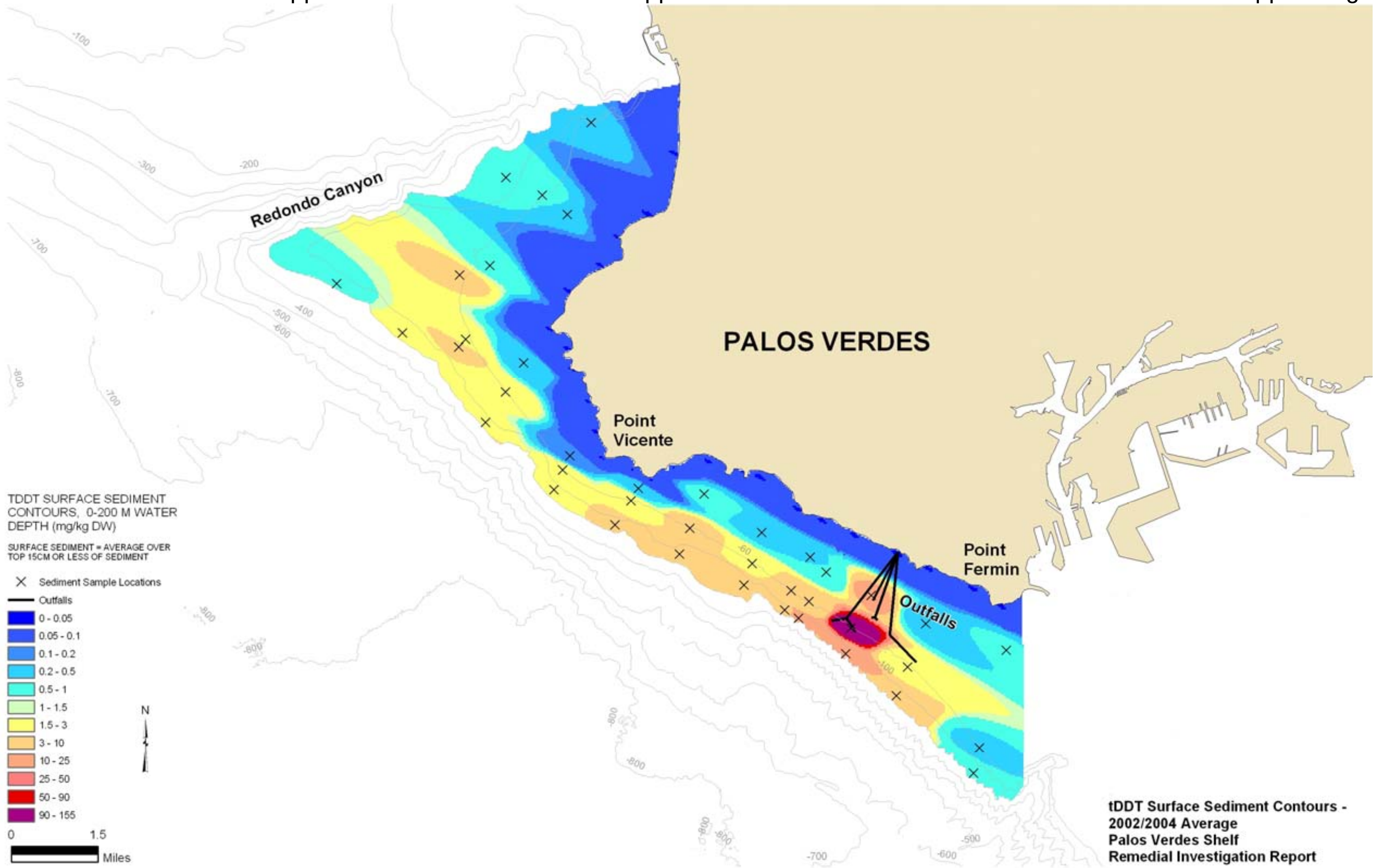
[10] For more information please see http://www.darrp.noaa.gov.
[11] Barnett, AM , SM Bay, KJ Ritter, SL Moore, SB Weisberg. 2007 Sediment quality in California bays and estuaries. Technical Report 522. Southern California Coastal Water Research Project Costa Mesa, CA. 2007.

Figure 1**. (DDT deposit map): The effluent-affected (EA) deposit per million) at the outfalls.** As the deposit fans out to the northwest, concentrations less than 1 ppm closer to shore and 3 to 15 ppm over contaminant concentrations in the 100 to 200 ppm range.



Data Source: EPA 2008. http://www.epa.gov/region09/waste/sfund/pvshelf/

Table 3. Benthic response index (BRI) and the correlating descriptors for each reference level

Benthic Response Level	Benthic Condition	Coastal Sites	BRI Description
Reference	Good	Reference	• Reference communities are expected to occur at undisturbed sites
Level 1	Good	Marginal deviation	• At Response Level 1, communities exhibit some indication of stress, but only within the measurement variability of reference conditions.
Level 2	Poor	Biodiversity loss	• At Response Level 2, communities exhibit clear evidence of physical, chemical, other anthropogenic, or natural stress.
Level 3	Poor	Community function loss or defaunation	• At Response Level 3 communities exhibit a high magnitude of stress.

Data Source[12]

Impaired Water Bodies

When a water body does not meet established water quality standards, it is placed on an impaired waters list mandated by section 303(d) of the federal Clean Water Act. For this reason, this list is often called the 303(d) list, and waters on this list are referred to as “impaired” waters. Typically, a total maximum daily load (TMDL) is developed for each impaired water body. A TMDL determines the total amount of the pollutant/stressor (e.g., pathogens, sediment, nutrients) that the water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources[13]. Not all pollutants listed in the 303(d) list are harmful to the marine ecosystem. Bacteria and other pathogens are 303(d) listed because they may be harmful to humans during recreational activities. Most of these sites occur along the beaches. The data for impaired water bodies are presented on maps 1b, 2b, 3b and 4b.

Descriptions of Layers on the “Areas of Water Quality Opportunities” Map

A separate map, with only one data layer, has been created for the SCRSG’s use. This map is labeled the “Areas of Water Quality Opportunities.” This map contains the ASBS data layer. SCRSG members can use this map to guide them towards the most suitable places to place an MPA with regard to water quality.

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[12] Ranasinghe, J.A., A.M. Barnett, K.C. Schiff, D.E. Montagne, C. Brantley, C. Beegan, D.B. Cadien, C. Cash, G.B. Deets, D.R. Diener, T.K. Mikel, R.W. Smith, R.G. Velarde, S.D. Watts and S.B. Weisberg. 2007. Southern California Bight 2003 Regional Monitoring Program: III Benthic Macrofauna. Southern California Coastal Water Research Project Authority. Costa Mesa, CA.

[13] USEPA. 2008. Introduction to TMDLs. http://www.epa.gov/owow/tmdl/intro.html#definition (accessed 07/29/08)..

ASBS Data Layer

Areas of special biological significance (ASBSs), which were established through the California Ocean Plan, are a subset of State Water Quality Protection Areas (SWQPAs). These areas are protected from waste being discharged into them, affording better and more natural water quality. Areas proposed for ASBS designation should have the potential to benefit from protection beyond that offered by standard waste discharge restrictions and other measures, due to the highly regulated components of ASBSs. As previously mentioned, co-locating MPAs near ASBSs may offer a more complete package of protection. ASBSs are presented in maps 1c, 2c, 3c and 4c,

Description of Mussel Watch Data

Since 1975 the California Department of Fish and Game has operated the California State Mussel Watch and its freshwater equivalent, the Toxic Substances Monitoring Program, under interagency agreement with the California State Water Resources Control Board. This program is a long-term water quality trends monitoring program and transplants mussels to evaluate coastal water quality conditions[14].

The National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends Mussel Watch Program was created in 1986 and it is designed to monitor chemical contamination in coastal waters. The program is based on yearly collection and analysis and uses these bivalves to measure the contaminants in the water by measuring the level of contaminants in the bivalve's tissues. Contaminants found in the tissue are a good indicator of local contaminaiton in the environment. This program now measures nearly 140 different contaminents[15]. The national mussel watch data is better at capturing particular areas of concern, because the sites are located fairly regularly and along important features along the coast and can be used to provide an overall assessment, whereas the state's program primarily targets areas with known or suspected impaired water quality and is not intended to give an overall water quality assessment.

We will examine data from the NOAA mussel watch report with a focus on the sites that had medium to high concentrations of contaminents. The medium to high range is relative to other sites throughout California. Due to the complexity of these reports, we are only going to focus on the four contaminants; Copper, DDT, PAHs, and PCBs. (For more information and finer detail on these reports, please see footnotes 8 and 9). In addition, it is important to note that these studies are only relevant in terms of the effect these pollutants have on humans. Since very few studies exist for the effects on wildlife, these data will be used as a surrogate to gauge the potential for contaminant effects on wildlife.

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[14] State Water Resources Control Board. 2000. State mussel watch program 1995-1997 data report. Web Source: http://www.waterboards.ca.gov/water_issues/programs/swamp/mussel_watch_9597.shtml.

[15] Kimbrough, K. L., W. E. Johnson, G. G. Lauenstein, J. D. Christensen and D. A. Apeti. 2008. An Assessment of Two Decades of Contaminant Monitoring in the Nation's Coastal Zone. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 74. 105 pp. Web Source: http://ccma.nos.noaa.gov/about/coast/nsandt/welcome.html.

The use of DDT, a POP and an organocholorine pesticide (OCP), was banned in Europe and the U.S. in the 1970's. Documented evidence has shown the influence OCPs have on biological organisms[16,17]. Pesticides applied to land find their way into the marine sediments through rain runoff or rivers and streams. Here they settle and the degradation rates, either natural or biologically, are very low. DDT biocaccumulates in organisms, which are highly sensitive to this compound. In the study region, there are nine sites that have levels of DDT that have medium to high concentrations when compared to sites in the rest of the state. These locations are near Harbor Island in San Diego Bay, Oceanside Beach jetty, the west jetty in Anaheim Bay, Long Beach breakwater, Cabrillo Pier in the Los Angeles Harbor, the Royal Palms area of Palos Verdes, Redondo Beach jetty, south jetty in Marina Del Ray and Las Tunas Beach in Santa Monica Bay.

Industrial contributors to total POPs in environmental samples come from PCBs. These are synthetic compounds which have up to 209 congeners that differ widely in their toxicological properties. Commercial uses for PCBs can be found as fluids in transformers and capacitors, hydrolytic fluids, lubricating oils and as additives to pesticides, paints and ink. The physiological effects of these toxins on a biological system can contribute to negative growth and reduced reproductive efforts[18]. In the study region, there are two sites that have medium to high concentrations when compared to sites in the rest of the state. These sites are located near the Coronado Bridge and Harbor Island in San Diego Bay.

The most ubiquitous pollutants among the POPs are the polycyclic aromatic hydrocarbons (PAHs) and are defined by containing two or more fused rings. PAHs have two types of anthropogenic sources: petrogenic, which are derived from natural petroleum-related sources, and pyrogenic, which are the byproducts of burning fossil fuels and other hydrocarbons, such as natural brush or forest fires. PAH's stability coupled with the carcinogenic properties of some compounds have led to greater interest in understanding the effects and distribution among aquatic ecosystems[19]. In the study region there are four sites that have levels of PAHs with medium to high concentrations compared to sites in the rest of the state. These sites are located near Coronado Bridge in San Diego Bay, Harbor Island in San Diego Bay, Cabrillo Pier in the Los Angeles Harbor, and the south jetty in Marina Del Ray.

Trace amounts of copper are an essential nutrient for plants and animals but copper can be toxic to aquatic organisms; juvenile fishes and invertebrates are much more sensitive to copper than

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[16] Pant, N., Mathur, N., Banerjee, A.K., Srivastava, S.P. Saxena, D.K. (2004). Correlation of chlorinated pesticides concentration with seminal vesicle and prostatic markers. *Reproductive Toxicology* 19: 209-214.
[17] Damstra, T (2002). Potential effects of certain organic pollutants and endocrine disrupting chemicals on the health of children. *Journal of Toxicology: Clinical toxicology* 40:4 457-465.
[18] Sauer, P.J.J., Huisman, M., Koopman-Esseboom, C., Morse, D.C., Smits-van Prooije, A.E., van de Berg, K.J., Tuinstra, L.G.M.Th., van der Paauw, C.G., Boersma, E.R., Weisglas-Kuperus, N., Lammers, J.H.C.M., Kulig, B.M., Brouwer, A. 1994. Effects of Polychlorinated Biphenyls (PCBs) and Dioxins on Growth and Development. *Human and Experimental Toxicology* 13: 900-906.
[19] Zeng, E.Y. and Vista, C.L. (1996). Organic pollutants in the coastal environment off San Diego, California. 1. Source Indentificatin and assessment by compositional indices of polycyclic aromatic hydrocarbons. *Environmental Toxicology and Chemistry* 16:2 179-188.

adults fishes[12]. Anthropogenic sources of copper come from antifouling ship paint, naufacturain, wood preservative and vehicle brake pads to name a few. (For more information on copper see footnotes 20 and21). The three highest levels of copper in the study region occurred at Coronado Bridge in San Diego Bay, Harbor Island in San Diego Bay and near the Cabrillo Pier in the Los Angeles Harbor.

Other Information

Hypoxia

Low oxygen concentrations can occur in the sections of enclosed bays and estuaries that: 1) have restricted tidal exchange or flushing, and/or 2) receive excessive nutrient or organic enrichment contributing to biochemical oxygen demand or periodic algal blooms. This is mostly a local problem in certain embayments on the mainland coast. This information is not presented on the maps.

4. Potential Post-MPA designation Implementation Strategies to Protect and Restore Water Quality

Marine water quality will undoubtedly play a role in the success of MPAs. It is generally accepted that degraded water and sediment quality results in impacts to marine life, including undesirable changes to community structure and function[22,23,24,25]. Since the State Water Resources Control Board and the regional water quality control boards have primary responsibility for regulating water quality, the water boards should be informed of potential water quality concerns for MPAs. For example, the regional water boards may recommend to the state board the designation of additional state water quality protection areas, or work on priority total maximum daily loads that could restore water quality in MPAs.

Monitoring MPAs is extremely important to track their status and effectiveness. Similarly, in intake systems, discharge areas (e.g., sewage outfalls and large storm drainages), and in ASBSs. In fact, biological monitoring for water quality purposes often includes fish, macrobenthos and benthic community condition (e.g., abundance and diversity) measures, which also are often used

[20] ATSDR (Agency for Toxic Substances and Disease Registry). 2004. Toxicological Profile for Copper. September 2004.
[21] Denier van der Gon, H.A.C., Hulskotte, J.H.J.AVisschedijk, .J.H, and Schaap, M. 2007. A revised estimate of copper emissions from road transport in UNECE Europe and its impact on predicted copper concentrations. *Atmospheric Environment* 41 (38):8697-8710.
[22] Guidetti, P., Terlizzi, A., Fraschetti,S. Boero, F. 2003. Changes in Mediterranean rocky-reef fish assemblages exposed to sewage pollution. *Marine Ecology Progress Series* 253:269–278.
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[24] Islam, S. and Tanaka, M. 2004. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. *Marine Pollution Bulletin* 48 (2004) 624–649.
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to inform MPA monitoring. MPA and water quality monitoring efforts should be coordinated and collaborative in nature in order to leverage and stretch finite monetary resources while developing the best information possible.

This work should set the stage for future collaboration between managing agencies and the water boards to restore and protect water quality in MPAs, and provide information in developing monitoring programs during the implementation phase of the MLPA.