California MLPA Master Plan Science Advisory Team

Draft Recommendations for Considering Water Quality and Marine Protected Areas in the MLPA North Coast Study Region

Revised March 9, 2010

The purpose of this document is to provide guidance and additional information to assist 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 Maser Plan Science Advisory Team (SAT) Water Quality Work Group's recommendations for post-MPA implementation strategies to protect and restore water quality.

This document is divided into four sections:

1. Background
2. Stakeholder consideration of water quality in the MLPA North Coast Study Region
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 North Coast Study Region

Water quality[1] is a concern in the MLPA North Coast Study Region (NCSR) 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. However, it is important to note that coastal water quality in most portions of this study region is very good, due to the lack of development as compared to other parts of the California coast.

[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.

It is recommended to consider avoiding the location of proposed MPAs in areas of poor or threatened water quality, such as at municipal sewage or industrial outfalls, and in areas that are significantly impacted by a variety of pollutants from developed urban or agricultural watersheds in the study region. Underlying oceanographic patterns and other abiotic factors should also be considered.

In the MLPA South Coast Study Region, the SAT recommended avoiding cooling water intake sites for power plants. However only one major coastal power plant using once-through cooling is located in the NCSR, and that is the Humboldt Bay Power Plant. This plant is completing its re-powering project in early 2010, and will be fully converted to closed-cycle cooling by the end of 2010. Therefore, in the NCSR, there are no cooling water intakes that should be avoided.

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 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 identify water quality issues during the development of MPA proposals. The first set of maps (Map 1a and Map 2a) is labeled “Areas of Water Quality Concerns” and the second set (Map 1b and Map 2b) is labeled “Water Quality Areas of Opportunity”. These two sets of maps consist of data layers that will be described in detail below. The maps should be used to identify areas of water quality concerns and caution should be exercised when proposing MPAs in these designated areas.

The 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 in the NCSR:

- ***Urban storm drain and other non-point source pollutants*** are known to be toxic to larvae. Pollutants from stormwater discharge sites usually only pose a threat following big rainstorms. However the plumes are not much of a threat to older life stages that have sufficient mobility to avoid them. Pollutants from other non-point source locations, such as port and harbors, may be more persistent year round, often accumulating in the sediment and negatively influencing benthic epifauna and infauna species the most. Agricultural runoff, which can contain pesticides, animal wastes and fertilizers, also poses a threat.

- ***Wastewater effluents*** are of concern because sediments in their immediate vicinity sometimes have elevated contaminant concentrations relative to background. However, they are usually of less concern than storm runoff because treated wastewater effluents, even before dilution in the receiving environment, are not usually toxic to biota. Even though the sediments near the outfall are rarely highly toxic, 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 for the NCSR, 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 impaired water bodies, mussel watch data, and a brief summary of hypoxia, wave energy, and a brief discussion on the removal of the dams on the Klamath River, which will all be described below.

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

Stormwater and other Non-Point Discharge Sites

One source for contaminants entering the study region is urban storm water, with untreated stormwater being discharged from numerous storm drains during wet weather. While the NCSR is mostly open space, there are Phase II storm water National Pollutant Discharge Elimination Permit System (NPDES) areas along the coast. Phase II permits are issued to municipalities or other public entities with small municipal separate storm sewer systems (MS4s). An MS4 is primarily designed to collect and transport stormwater. The system may include roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains. MS4s are not part of a publicly owned treatment works nor are they combined with sewer lines. Urban stormwater discharge has the potential to cause impairments by “(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”[2]. The third of these impacts most directly pertains to the MLPA. The Phase II stormwater permit areas shown on Map 1a and Map 2a are located in Arcata, Eureka, Fort Bragg, Fortuna, and McKinleyville.

Nonpoint source pollution is also a concern within the NCSR. Nonpoint sources include urban runoff not covered under a stormwater NPDES permit, agricultural runoff, timber harvest and marinas/harbors. Agricultural runoff may result in the discharge of nutrients, sediments, and

[2] 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.

pesticides into nearby estuarine habitats or in coastal waters adjacent to agricultural areas[3]. These pollutants may degrade aquatic habitats by causing eutrophication, sedimentation, and more importantly, toxicity to marine and estuarine species[4]. Many of the more substantial coastal agricultural areas in the NCSR happen to be located in association with MS4s, such as near Arcata, Eureka, Fort Bragg, Fortuna, and McKinleyville. Timber harvest and forestry practices may cause an increase in river sedimentation[5], however it is an open question as to the level of impact that anthropogenic sediment discharges have on marine biota in the NCSR. Harbors and marinas may have higher levels of nonpoint source pollutions from antifouling paint, oil from boats, detergents from septic systems, and various pollutants derived through harbor development and should be avoided.

Table 1. Locations where stormwater and nonpoint source discharge occurs within the north coast study region

Nonpoint Source Areas of Concern	Source of Concern
Crescent City	Urban runoff and harbor development
Klamath River	Blue green algae blooms from upstream agriculture and dams
Trinidad	Urban runoff and harbor development
Mckinleyville	Urban and agricultural runoff
Arcata	Urban and agricultural runoff
Eureka	Urban runoff, aquaculture, and harbor development
Fortuna and surrounding communities on the Eel River	Urban and agricultural runoff and harbor development
Shelter Cove	Urban runoff and harbor development
Fort Bragg	Urban and agricultural runoff

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 and federal agencies. The origin of these point sources in the NCSR include municipal wastewater treatment and disposal systems, industrial wastewater disposal, and research marine laboratories (Table 2).

The point source discharge sites have been broken out by major, intermediate and minor impact ratings[6]. Point source sites with a major and intermediate pollution rating deserve more attention and have a larger effect on the surrounding environment. There is only one major wastewater discharge in the NCSR and that is the Samoa Pulp Mill; pulp mills have been

[3] Stuart, D., 2010. Coastal ecosystems and agricultural land use: New challenges on California's central coast. Coastal Management 38 (1), pages 42 – 64.
[4] Schultz, R., 2004. Field studies on exposure, effects and risk mitigation of aquatic nonpoint-source insecticide pollution: a review. Journal of Environmental Quality 33 (2), pages 419–448.
[5] Binkley, D. and T. Brown. 1994. Forest practices as nonpoint sources of pollution in North America. Water Resources Bulletin 29 (5), pages 729 -740.
[6] These ratings used by the SAT are different than the rating system used by the US EPA.

known to discharge dioxins, which are highly toxic. This facility was not discharging when this document was prepared but an application for discharge has been submitted to the North Coast Regional Water Quality Control Board, and a permit may be issued in 2010.

Numerous parameters influence the extent of impacts from these point sources of pollutants, including oceanographic conditions, output flow, and the concentration of pollutants when dispersed at the source. Considering these parameters the SAT is designating a 0.5 mile radius zone of impact around major discharges and a 0.25 mile radius zone of impact around intermediate discharges as a typical or average extent of impacted area. It is important to note that these zones of impact represent the SAT's best professional judgment and have been subjectively deduced from available data[7]. Thus, the 0.5 mile and 0.25 mile radius areas for major and intermediate dischargers respectively should be considered a conservative estimate of the zone of impact. The actual impacts at any discharge point could be larger or smaller. These zones of impact are represented on Maps 1a and 2a around the major and intermediate outfalls, including any associated diffusers. Zones of impact were not assigned to minor wastewater plants but their outfall points should still be avoided. It also should be noted that the Eel River watershed includes seven permitted municipal and industrial wastewater outfalls which discharge during wet weather to the Eel River or its tributaries; therefore the mouth of the Eel River into the southern portion of the estuary should also be avoided if possible.

Undersea wastewater discharge pipes and diffusers occupy space on the seafloor and represent an anthropogenic change to natural habitat. Certain discharge structures have an auxiliary outfall, often closer to shore, to be used in emergencies or during certain planned maintenance periods; discharges from these auxiliary outfalls are rare. The wastewater agencies must perform maintenance on these structures, and that activity has the possibility of disturbance to habitat and benthic organisms. Furthermore permittees are required to perform monitoring, which in some cases involves collecting and sacrificing marine life, and may cause some habitat disruption (e.g., research vessel trawling impacts).

Table 2. National Pollutant Discharge Elimination System list for industrial and wastewater facilities within the MLPA North Coast Study Region

Discharge Location	Effluent
	Major Discharges
Samoa Island Pulp Mill/Fairhaven Power	Lumber (pulp) mill wastewater and cooling water
	Intermediate Discharges
Crescent City	Treated sanitary wastewater and seafood wastes
City of Arcata	Treated sanitary wastewater
Sierra Pacific Industries Arcata Division	Lumber (pulp) mill wastewater
City of Eureka	Treated sanitary wastewater
Fort Bragg, City of	Treated sanitary wastewater
Fortuna and other Eel River Communities*	Treated sanitary wastewater, cooling water and industrial wastewater

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

Discharge Location	Effluent
	Minor Discharges
CSU Humboldt	Marine lab waste seawater
Pacific Gas and Electric	Industrial wastewater
Shelter Cove Waste Water Plant	Treated sanitary wastewater
Shelter Cove Fish Cleaning Station	Seafood wastes
Mendocino City	Treated sanitary wastewater

**Eel River watershed NPDES discharges include Fortuna, Redwood College, Ferndale, Scotia, Rio Del, Redway, and Willits.*

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

A separate map, with only one data layer, has been created; this map is labeled the "Areas of Water Quality Opportunities." This map contains the ASBS data layer, which can be used to guide toward the most suitable places to place an MPA with regard to water quality.

ASBS Data Layer

Areas of special biological significance (ASBSs), which were established through the California Ocean Plan, are a subset of SWQPAs. These areas are protected from waste being discharged into them, affording better and more natural water quality. MPAs proposed within an ASBS should have the potential to benefit from protection beyond that offered by standard waste discharge restrictions and other measures, due to the strict water quality protections in ASBSs. As previously mentioned, co-locating MPAs near ASBSs may offer a more complete package of protection. ASBSs are presented in Maps 1b and 2b.

Description of Mussel Watch Data

Historically the California Department of Fish and Game 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 represented a long-term water quality trends monitoring program using transplanted mussels to evaluate coastal water quality conditions[8]. This program is now greatly limited due to reduced funding.

The National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends Mussel Watch Program was created in 1986 and it is also designed to monitor chemical contamination in coastal waters. The program is based on bi-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 has historically measured nearly 140

[8] 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.

different contaminents[9]. 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 previous state program primarily targets areas with known or suspected impaired water quality and is not intended to give an overall water quality assessment. Since 2007 the California State Water Resources Control Board and the Southern California Coastal Water Research Project have been collaborating with NOAA Mussel Watch Program to expand the number of sites in California. In 2010 the NOAA/California collaboration is focusing on contaminants of emerging concern such as endocrine disrupters, other pharmaceuticals, and current use pesticides.

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. These data are important in understanding water quality concerns, but will not be used in evaluating MPA proposals by the working groups.

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[10,11]. 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 bioaccumulates in organisms, which are highly sensitive to this compound. In the study region, there were zero sites sampled that have levels of DDT with medium to high concentrations when compared to sites in the rest of the state.

Industrial contributors to total POPs in environmental samples come from Polychlorinated biphenyls (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[12]. In the study region, there are zero sites

[9] 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.

[10] 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.

[11] 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.

[12] 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,

that were sampled that have medium to high concentrations when compared to sites in the rest of the state.

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[13]. In the study region there are zero sites sampled that have levels of PAHs with medium to high concentrations compared to sites in the rest of the state.

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 adult 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 14 and 15). The highest level of copper found in the study region occurs at Point St George. None of the other sites sampled had copper levels higher than 16 ppm.

Other Information

Sediment Contamination Sample Sites

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 persistent organic pollutants, such as DDT and PCBs, become introduced into the marine environment, settle into the sediment and bioaccumulate through the food web, beginning with the benthic organisms[16]. These compounds have toxic effects on animal reproduction, immunological functions, and development[17]. Not only do the pollutants pose a threat to the marine

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B.M., Brouwer, A. 1994. Effects of Polychlorinated Biphenyls (PCBs) and Dioxins on Growth and Development. *Human and Experimental Toxicology* 13: 900-906.
[13] 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.
[14] ATSDR (Agency for Toxic Substances and Disease Registry). 2004. Toxicological Profile for Copper. September 2004.
[15] 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.
[16] 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.
[17] 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.

organisms, after being integrated into the food web, they may pose a threat to humans as carcinogens or mutagens.

In bays and estuaries, a comprehensive approach has been developed to use three lines of evidence to create 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[18]. Data that use this approach is available for only Humbodlt Bay and the Eel River Estuary.

Humboldt Bay is a marine embayment located along the central coast of Humboldt County. Humboldt Bay is the second-largest estuary in California, after San Francisco Bay, and consists of Arcata (North) Bay at its north end, Central Bay, and South Bay. Sediment contamination in the Humboldt Bay is most prevalent in the northern portion of the bay (see Figure 1). Years of untreated discharge into the bay from various saw mills have left legacy contaminants of dioxins, which are highly stable compounds, have slow degradation rates,and are known environmental toxins[19]. In response to this, Humboldt Bay has also been placed on the List of Impaired Water Bodies (Section 303(d) of the federal Clean Water Act) for dioxin toxic equivalents and for polychlorinated biphenyls (PCBs).

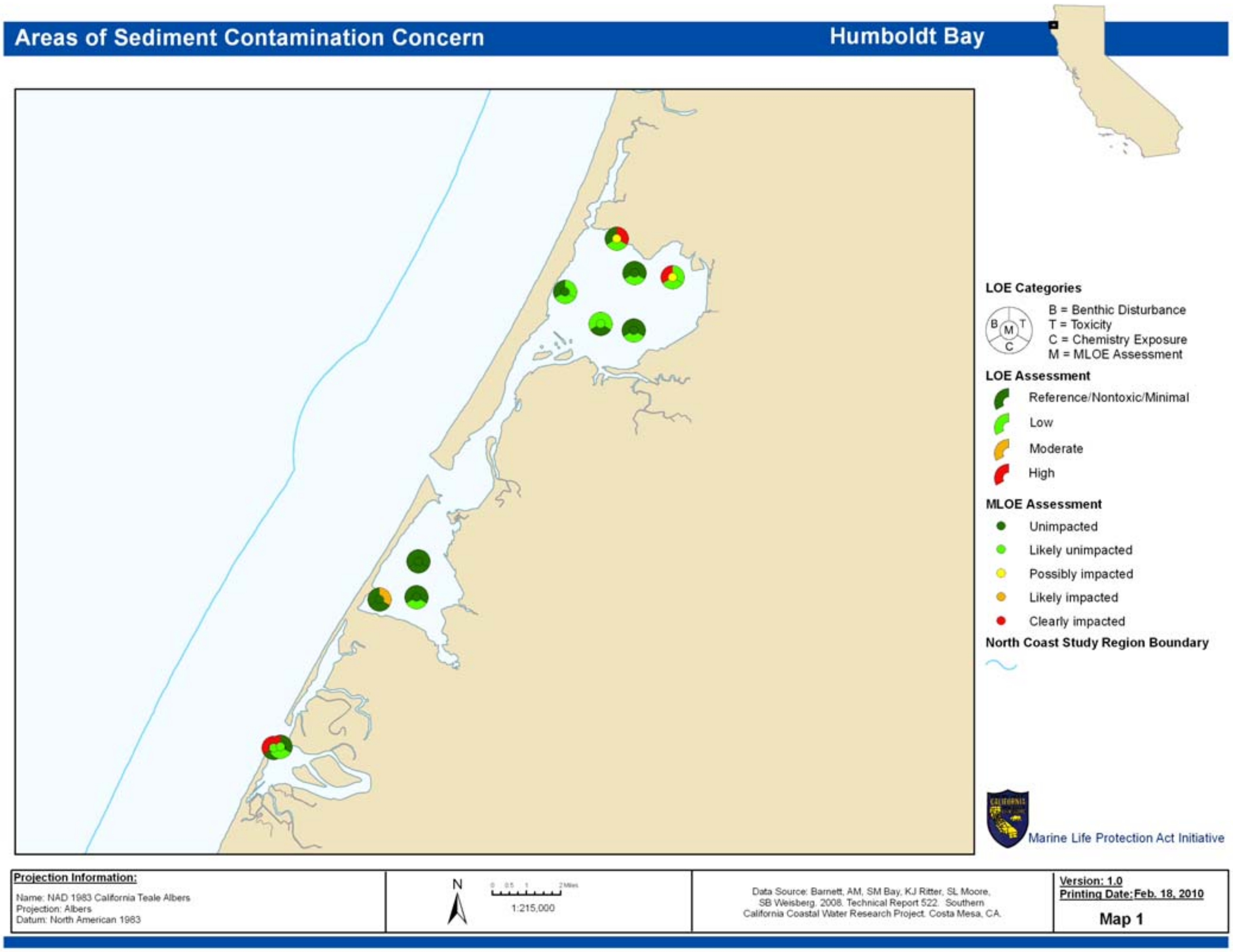
The Eel River Estuary receives pollutant inputs from the Eel River watershed, which includes several wastewater, stormwater and agricultural sources. While this estuary is not 303d listed, there is evidence that the benthic condition at its outlet to the ocean is disturbed. The other lines of sediment quality evidence (toxicity and chemistry) do not support more than a “likely unimpacted” sediment quality score as shown on Figure 1. However, the benthos may be impacted by poor water quality and/or physical disturbance.

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[20]. 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 the 303d listings in the NCSR are for watershed impairments, for example stream temperature, sediment and turbidity, except for Humboldt Bay as described previously. These data will not be used in evaluating MPA proposals but are provided for more background information.

[18] 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.
[19] Mandal, PK. 2005. Dioxin: a review of its environmental effects and its aryl hydrocarbon receptor biology. *J. Comp Physiol. B*. 175, pages 221-230.
[20] USEPA. 2008. Introduction to TMDLs. http://www.epa.gov/owow/tmdl/intro.html#definition (accessed 07/29/08).

Figure 1. Assessed sediment condition and line of evidence (LOE) categories at individual stations surveyed in Humboldt Bay[18]



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. The Klamath River is 303(d) listed for low dissolved oxygen, nutrients and toxic blue green algal blooms.

Wave Energy

Hydrokinetic technologies produce renewable electricity by harnessing the energy associated with the motion of a body of water (kinetic energy). The Federal Energy Regulatory Commission (FERC) has issued two preliminary permits for the development of hydrokinetic technologies in the north coast study region – both for wave energy: a permit for the GreenWave Mendocino Wave Park, and a permit for PG& E Humboldt Wave Connect. GreenWave Energy Solutions LLC has selected a 17 mi^2 section of ocean off Mendocino County near the city of Mendocino in hopes of eventually testing the feasibility of wave power. The PG&E Humboldt Wave Connect project is a 20 mi^2 area located offshore of Humboldt Bay. While the generation of electricity by hydrokinetic devices does not produce harmful air emissions, further research is necessary to determine what other types of environmental impacts may result from trapping the energy in waves and currents. The hope is that the environmental impacts of well-designed wave farms will be minimal, some of the concerns associated with a full-scale array of hydrokinetic devices include fish strike or impingement, sediment disruption, noise, and the potential to hinder movements of aquatic species – as well as potential minor changes in wave dynamics which could affect coastal habitats such as kelp forests or nearshore soft bottom habitats[21],[22].

Klamath River Dams

In 2009, twenty-eight parties including California, Oregon, American Indian tribes, federal agencies, conservation groups and Pacificorp (the utility company) signed onto a draft agreement to remove four hydroelectric dams on the Klamath River. If the agreement is carried out then the dams will be removed by 2020. Dam removal may affect monitoring, but will be a short term event relative to the time any MPA should be in place.

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[21] Cada, G., J. Ahlgrimm, M. Bahleda, T. Bigford, S.D. Staurakas, D. Hall, R. Moursund, and M. Sale. 2007. Potential impacts of hydrokinetic and wave energy conversion technologies on aquatic environments. Fisheries 32: 174-181.

[22] Nelson, P.A., D. Behrens, J. Castle, G. Crawford, R.N. Gaddam, S.C. Hackett, J. Largier, D.P. Lohse, K.L. Mills, P.T. Raimondi, M. Robart, W.J. Sydeman, SA Thompson, S. Woo. 2008. Developing Wave Energy in Coastal California: Potential Socio-economic and Environmental Effects. California Energy Commission, PIER Energy-Related Environmental Research Program, and California Ocean Protection Council CEC-500-2008-083.

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[23,24,25,26]. 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 Water Resources Control Board the designation of additional SWQPAs, 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. Similar monitoring is important 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 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.

[23] 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.
[24] 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.
[25] 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.
[26] Allen, M. J. 2006. Pollution. Pp. 595-610 *i*n : L.G. Allen, D.J. Pondella, and M.H. Horn (eds). The Ecology of Marine Fishes: California and Adjacent Waters. University of California Press, CA.