CARLSBAD DESALINATION PLANT: BRINE MIXING ZONE HABITAT ASSESSMENT

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Technical Memorandum

Prepared for:
Poseidon Water
Carlsbad, California

Prepared by:

MBC *Applied Environmental Sciences*
Costa Mesa, California

PROJECT STAFF

Poseidon Water

Peter MacLaggan

Josie McKinley

MBC *APPLIED ENVIRONMENTAL SCIENCES*

Eric Miller – Project Manager

Shane Beck

Jennifer Rankin

HDR

Eric Miller

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TECHNICAL MEMORANDUM

INTRODUCTION

Poseidon Water's Carlsbad Desalination Plant (CDP) is co-located with the once-through-cooled Encina Power Station (EPS) where it uses the existing intake and discharge infrastructure. According to the EPS Tentative Order R9-2016-002 (pg. F-15):

> *The cooling water and brine flows into a discharge pond before discharging into a riprap-lined channel, a surface jet discharge, and then into the Pacific Ocean (Discharge Point 001).* Aerial image provided in Figure 1.

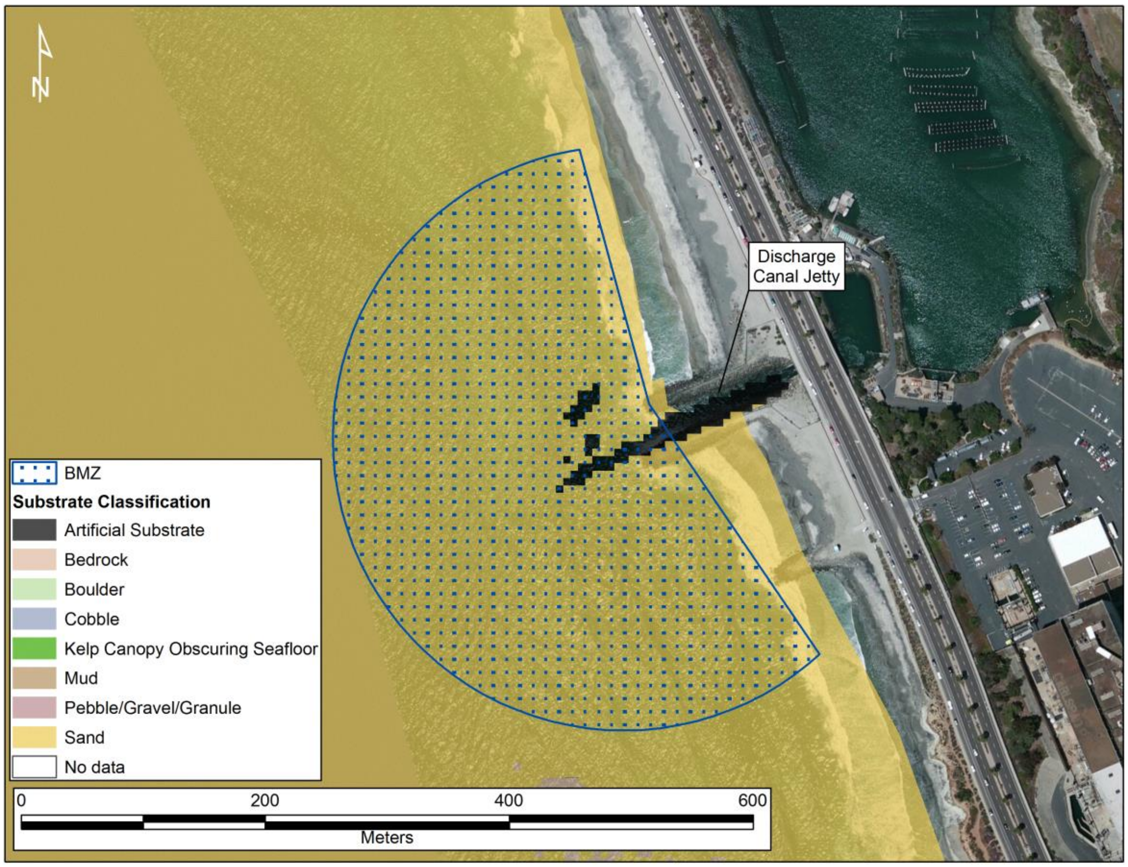

FIGURE 1. AERIAL IMAGE OF AGUA HEDIONDA LAGOON AND NEARSHORE ZONE SHOWING THE DISCHARGE CANAL, BRINE MIXING ZONE (BMZ), AND BENTHIC HABITATS. BENTHIC HABITAT INFORMATION FROM SANDAG (2012).

The existing CDP Order R9-2006-0065 does not specifically describe the discharge other than to refer to the EPS discharge channel (pg. F-6). Per the above definition, the CDP discharge channel constitutes material placed for the purpose of directing the EPS (and now CDP) effluent to the receiving waters. Therefore, all habitat in the discharge canal is considered artificial, consistent with the designation assigned by

San Diego Association of Governments (SANDAG) nearshore coastal zone seafloor substrate characterization (SANDAG 2012; Figure 1). Poseidon has agreed to include the full footprint of rocky jetties in mitigation calculations. Together, these two jetties comprise 0.92 acres of rocky habitat.

During operation, the CDP discharges waste brine to the ocean via the existing EPS discharge canal. Per §M.3.d of the California Ocean Plan (OP), the CDP qualified to use an alternative Brine Mixing Zone (BMZ). Jenkins (2016) modeled the discharge plume and determined the BMZ would extend 200 meters (m) away from the end of the discharge canal. The OP defines the BMZ as the area in which the brine plume undergoes natural mixing with the ambient receiving waters to result in a salinity of no more than 2 parts per thousand (ppt) more than ambient, or typically 35.5 ppt at the edge of the BMZ. California Ocean Plan §M.2.e.(1) requires the development of a *Marine Life Mortality Report* to delineate, among other things the area subject to operational mortality within the BMZ (§M.2.e(1)(b)). This area described in the *Marine Life Mortality Report* is also subject to mitigation per §M.2.e.3(b)iii. To this end, §M.2.e.3(b)vi allows for mitigation ratios when out-of-kind mitigation is used wherein low productivity habitat, such as open water or soft-bottom habitat, is impacted and high productivity habitat (estuarine and intertidal wetlands, rocky reefs, etc.) is restored. The Regional Water Board may increase the mitigation ratio based on an assessment of the impacted habitat and proposed mitigation. However, a ratio of no greater than one acre of mitigation habitat for every 10 acres of impacted habitat is specified in §M.2.e.3(b)vi. Per §M.2.e.3(b)ix, Poseidon Water is required to document the rationale for the mitigation ratio requested. In prior regulatory proceedings, San Diego Regional Water Quality Control Board approved Poseidon's proposal to restore intertidal estuarine/wetland habitat in South San Diego Bay (Dudek 2016). Here we review the existing conditions relevant to the BMZ and propose a mitigation ratio based on the productivity of the existing BMZ habitat as compared to that of the proposed restoration project.

PRE-OPERATIONAL ENVIRONMENTAL SETTING INSIDE BRINE MIXING ZONE

Available substrate habitat mapping and descriptions characterize the area underlying the BMZ as sandy bottom habitat (Figure 1; Dudek 2006). Per the Environmental Impact Report (Dudek 2006):

> *The area in the immediate vicinity of the discharge is sand with hard substrate* ***beginning*** *at approximately 2,200 ft* (671 m) *upcoast and 1,200–1,500 ft* (366–457 m) *downcoast of the discharge channel.* (Emphasis added)

The only hard substrate within the BMZ is rock placed to construct the discharge canal jetties which function as artificial habitat within the discharge structure and the BMZ.

As noted in Dudek (2006), no naturally occurring hard substrate exists within the area encompassed by the BMZ, or an area less than 200 m away from the point of discharge. The areas of hard substrate depicted in Elwany et al. (1999) used as Figure 2 in Jenkins (2016) represent the tips of the discharge canal jetties. The two jetties were constructed with large boulders creating habitat similar to natural rocky intertidal and shallow subtidal habitats. The EPS jetties have not been surveyed in recent years, but the resident fauna and flora should be similar to that documented on natural habitats as reported by the Multi-Agency Rocky Intertidal Network (MARINe 2017). Dominant intertidal taxa include mussels (*Mytilus* sp.), seastars (e.g. *Pisaster ochraceus*), sea anemones (e.g. *Anthopleura elegantissima*), barnacles (e.g. *Pollicipes polymerus*), In the shallow subtidal rocky habitat, example taxa include various surfperch (Family Embiotocidae), Garibaldi (*Hypsypops rubicundus*), gobies (Family Gobiidae), and various octopus examples (*Octopus* sp.) (Pondella et al. 2002).

Graham (2005) reviewed available reports on the marine biological resources surrounding the EPS discharge canal. The subtidal sand habitat near EPS was subject to seasonal changes caused by varying wave energies reaching the area and shifting sand volumes caused by seasonal replenishment or scouring. The area sediments were primarily colonized by an infaunal community dominated by polychaete worms and crustaceans (Table 1), consistent with community compositions across the Southern California Bight (Ranasinghe et al. 2012). Likewise, the bottom-associated fishes reported from the area (Table 1) were also consistent with those found in similar habitats throughout the Southern California Bight (Miller and Schiff 2011). No rare, threatened, endangered, or otherwise protected fish or marine invertebrate reportedly occurs in the BMZ. The BMZ is devoid of any known submerged aquatic vegetation limiting its primary production value to transient phytoplankton. Biogenic habitats like giant kelp (*Macrocystis pyrifera*) and surfgrass (*Phyllospadix* sp.) or other highly productive, natural, hard-bottom, coastal habitats occur at least 360 m away from the discharge or 160 m outside of the BMZ.

TABLE 1. LIST OF INFAUNAL INVERTEBRATES AND FISHES COMMON TO THE BMZ AREA AS LISTED BY GRAHAM (2005).

Infaunal Invertebrates	
Polychaete worm	*Prionospio pygmaeus*
Amphipod Crustacean	*Gibberosus* (*Megaluropus*)
Cumacean Crustacean	*Leptocuma forsmani*
Nemertean Worm	*Carinoma mutabilis*
Sea Spider	*Callipallene californiensis*
Pacific Sand Dollar	*Dendraster excentricus*
Fishes	
Speckled Sanddab	*Citharichthys stigmaeus*
Northern Anchovy	*Engraulis mordax*
Queenfish	*Seriphus politus*
Barred Sand Bass	*Paralabrax nebulifer*
White Croaker	*Genyonemus lineatus*
Hornyhead Turbot	*Pleuronichthys verticalis*
California Halibut	*Paralichthys californicus*

A habitat profile for the EPS receiving water soft-bottom habitat to be encompassed by the BMZ was developed using data from Figure 1 and from the Bight Regional

Monitoring Program's (Bight) 2008 survey (SCCWRP 2016). Data from The 2013 Bight were not publicly available as of November 2016 (S. Walther, personal communication). From these sources, the BMZ reportedly did not support any submerged aquatic vegetation, which does not include phytoplankton (Table 2). Soft-bottom demersal fish density in similar habitats had fish densities averaging 0.02 fish/m^2 (± 0.02 fish/m^2). Threatened or endangered species (Federal or State-listed) have not been reported in the EPS receiving waters.

TABLE 2. NATURAL RESOURCES REPORTED IN THE ENCINA POWER STATION RECIEVING WATERS (EPS RW), TIJUANA ESTUARY, AND MUGU LAGOON. THE NUMBER OF THREATENED OR ENDANGERED (T&E) SPECIES, AS PER FEDERAL AND STATE LISTS, IS INCLUDED FOR REFERENCE.

Natural Resource	EPS RW	Tijuana	Mugu[e]	Mitigation Ratio
Vegetation (Net prod. g C/m^2/y)	0	616[b]	1,680	>10:1
Fish (count/m^2)	0.02[a]	195[c]	13	650:1 to 9,750:1
Number of T&E Species	0	≥4[d]	5	>10:1
a-SCCWRP 2016; b-Zedler et al. 1992;c-Desmond et al. 2002;d-USFWS 2016; e-Onuf 1987				

In October 2015, prior to the commercial operation of the CDP, infauna were collected at three stations within the BMZ, three reference stations (200 m upcoast, downcoast, and offshore of the BMZ), and at one far-field reference station 2,000 m upcoast of the BMZ (Weston Solutions 2016). A total of 305 invertebrates from 61 distinct taxa were collected in the 42 samples (three replicates at each of the seven stations). Overall, mean species richness, diversity, and abundance were similar between the stations in the BMZ and outside the BMZ. Even though the diversity and abundance were similar among the sites surveyed (and similar to other nearshore, sandy habitats at comparable depths), they were relatively low compared to other soft-bottom habitats in southern California, such as habitats with finer sediments farther offshore, bays, and harbors.

APPROVED MITIGATION

As noted previously, the OP affords project owners the opportunity to use out-of-kind mitigation. In recent California cases, the preferred mitigation option has been the restoration or creation of highly productive estuarine or wetland habitat (WateReuse 2016). For illustrative purposes, published records for two existing estuaries were examined to highlight the productivity differences between the open-coast, soft-bottom habitat underlying the BMZ and estuaries. Tijuana Estuary and Mugu Lagoon are both used as reference sites for major wetland mitigation project monitoring (Page et al. 2016). Each has been studied with sufficient information reported to preform similar habitat characterizations as was described earlier for the EPS receiving waters. The

Tijuana Estuary located south of San Diego Bay reportedly has a vegetative community that produces 616 g of carbon (C)/m^2/year (net). The fish density at Tijuana Estuary was reported to be 195 fish/m^2. Like most estuaries, the Tijuana Estuary supports at least four threatened or endangered species. Mugu Lagoon also supports a robust vegetative community with net primary production of 1,680 g C/m^2/yr. The fish community in Mugu Lagoon is not as robust as Tijuana Estuary with an average density of 13 fish/m^2. The lagoon supports at least five threatened and endangered species. These reported habitat parameters for two estuaries provide a baseline for determining the appropriate out-of-kind mitigation ratio for the CDP discharge.

Building off prior surface water intake and discharge mitigation in California, Poseidon has entered into a Memorandum of Understanding (MOU) with the United States Fish and Wildlife Service (USFWS) to restore wetlands in the San Diego National Wildlife Refuge Complex (Complex; Dudek 2016). The San Diego Regional Water Quality Control Board adopted Resolution R9-2011-0028 approving the preliminary plan for restoring wetlands at the Otay River Floodplain Wetland Mitigation Site (Dudek 2016; USFWS 2016). The preferred alternative in the Draft Environmental Impact Statement (DEIS) (USFWS 2016) is to redistribute sediments in two areas of the Complex to promote sustained wetland habitat consisting of appropriate vegetation (Table 3).

TABLE 3. SPECIES COMPOSITION AND RECOMMENDED PROPAGATION METHOD FOR SALT MARSH AND TRANSITION ZONE HABITATS. (FROM USFWS 2016)

Habitat Type	Common Name	Scientific Name	Propagation Method
Low salt marsh	California cordgrass	*Spartina foliosa*	Plugs
Mid-salt marsh	Saltwort Salt marsh daisy Seablite	*Batis maritima* *Jaumea carnosa* *Suaeda esteroa*	Cuttings in rose pots Cuttings in rose pots Cuttings in rose pots
High salt marsh	Saltgrass Alkali heath Shoregrass Parish's pickleweed Sea lavender	*Distichlis spicata* *Frankenia salina* *Monanthochloe littoralis* *Arthrocnemum subterminale* *Limonium californicum*	Cuttings in rose pots Cuttings in rose pots Cuttings in rose pots Seed in rose pots Cuttings in rose pots
Transition zone	Alkali weed Boxthorn Shoregrass Parish's pickleweed Palmer's frankenia	*Cressa truxillensis* *Lycium californicum* *Monanthochloe littoralis* *Arthrocnemum subterminale* *Frankenia palmeri*	Seed in rose pots Cuttings in rose pots Cuttings in rose pots Seed in rose pots Cuttings in rose pots

Wetland and estuarine habitats can vary based on a variety of natural or design (in the case of restored or created habitats) characteristics. These include tidal mixing, bathymetry, freshwater inputs, etc. All of these abiotic factors ultimately determine the long-term ecological community in the habitat. Vertebrate and invertebrate communities further vary amongst these habitats based on the aforementioned abiotic factors, but also vary based on the vegetation that takes root in the area. The ultimate productivity of the wetland/estuary community can frequently be traced to the sustained vegetation as measured in grams of carbon created by photosynthesis contributed to the ecosystem. Quammen and Onuf (1987) reported on the biological dynamics and trophic interactions in Mugu Lagoon, California. Like San Diego Bay, Mugu Lagoon serves as one of California's few remaining coastal estuarine wetlands (Sutula et al. 2008). In Mugu Lagoon, estuarine vegetation had a net primary productivity of 1,680 g C/m^2/y (Quammen and Onuf 1987). Onuf (1987) did not document the productivity of higher trophic level organisms other than reporting fish and birds were more commonly observed in vegetated areas in comparison to unvegetated soft-bottom habitat. This is consistent with general ecological knowledge of these habitats. Vegetation, especially submerged aquatic vegetation, creates complex biogenic habitat that supports greater diversity and productivity in higher trophic level communities, hence its critical value exemplified by its inclusion among the Habitat Areas of Particular Concern under fishery management plans developed by the Pacific Fishery Management Council (PFMC 2016). The actual community parameters (diversity, productivity, etc.) depend on the same suite of abiotic factors that regulate the vegetation, as well as the type, health, and density of the vegetation.

HABITAT COMPARISON

The Final Substitute Environmental Document (SED; SWRCB 2015) provides guidance for determining the appropriate mitigation ratio when out-of-kind mitigation is used to mitigate impacts to low-productivity habitats using restoration/creation of high productivity habitats. Section 8.5.4.2 of the SED specifically describes a mitigation ratio scenario wherein open water over soft bottom substrate was impacted. Much of this discussion centers on entrained and impinged marine life rather than substrate. When mitigating the BMZ impacts, the chief focus is the substrate as the density of the brine will cause it to sink until it has sufficiently mixed to near-ambient salinities. Subsequent to mixing and reaching the target salinity of ambient plus 2 ppt, the plume is no longer impacting the marine environment and cannot be discerned from the receiving waters. Therefore, our comparison of the impacted and to-be-mitigated habitats centers on the substrate-associated flora and fauna.

The most demonstrable difference between the impacted habitat in the BMZ and approved mitigation is the vegetation planting included in the mitigation plan (USFWS 2016). No aquatic vegetation had been reported in the BMZ; therefore any vegetation added to the environment in the mitigated wetlands represents a 100% increase, or 1,680 g C/m^2/y (based on the Mugu Lagoon example) added to the marine environment to support higher trophic levels. With no aquatic vegetation present in the BMZ, a true ratio cannot be calculated. A conservative assumption is >10:1, estuarine:BMZ for habitats other than the EPS discharge canal. The discharge canal jetties represent artificial reefs that were colonized accordingly. For salinity impacts to these 0.92 acres, a 1:1 mitigation ratio would most readily comply with the OP mitigation requirements including the ratio derivation. The rocky habitat created by the discharge jetties represent high productivity habitat for which the OP requires a 1:1 mitigation ratio habitat: BMZ.

Like other estuaries, the Complex is presently home to several protected species such as the federally endangered light-footed Ridgeway's rail (*Rallus obsoletus levipes*), California least tern (*Sternula antillarum browni*), and the federally threatened green sea turtle (*Chelonia mydas*), among several others (USFWS 2016). All of these listed species will be unaffected by the BMZ, but will greatly benefit from the mitigation efforts through the increased productivity in the NWR caused by the restored vegetation and it cascading ecological improvements to support on higher trophic level organisms.

Prior research into the secondary and tertiary production rates of fishes from various marine habitats ranks the soft-bottom habitat, such as that occurring in the BMZ, among the least productive (Bond et al. 1999; Nordby 2009; Claisse et al. 2014). Claisse et al. (2014) summarized the secondary productivity of fishes at various ecosystems, including many from California. Coastal lagoons and estuaries, similar to the proposed CDP mitigation, were up to 12 times as productive as soft-bottom habitat (Table 4), and the total fish density was 600 times higher in the estuarine habitat than in the shallow soft-bottom habitat (Table 2). One important caveat to consider when comparing open coastal and estuarine fish productivity is the difference in ambient fish sizes. Using the Bight data, the fish lengths reported for catches in the bays and marinas (proxy for the estuaries) and the open coast inner shelf at depths less than 16 m, bay fishes were smaller than the shelf fishes (Figure 2). The peak size class on the shelf was 10 cm, while in the bays it was 6 cm. At the right hand tail of the histogram in Figure 2, there were some larger size classes that comprised a larger percentage of the bay catch. This caused a shift in the mean length, but the average shelf fish was still larger at 12 cm versus the 11 cm bay fish average. This size difference of the fish in each area is an important consideration as productivity estimates are based on fish weights. Therefore, if larger fish are more common in one habitat than the other, the productivity estimates will reflect that difference. The value of the estuarine fish community is routinely found in the nursery function estuaries provide for species that will later take up residence on the shelf, or deeper (Allen et al. 2006). Furthermore, the smaller sized fish are a vital forage base for the birds common to the estuaries, many of which are threatened or endangered due to habitat loss (Davis et al. 2006).

TABLE 4. PEER-REVIEWED BIOLOGICAL PRODUCTIVITY OF VARIOUS HABITATS RANKED IN ORDER OF BIOLOGICAL PRODUCTIVITY. THE ECOSYSTEM, BIOLOGICAL FISH PRODUCTION, AND RATIO OF EACH ECOSYSTEM LISTED TO THE SOFT-BOTTOM CALIFORNIA PRODUCTIVITY. DATA FROM CLAISSE ET AL. (2014).

Rank	Ecosystem	Fish production ($g/m^2/d$)	Ratio	Reference
3	Estuary, Louisiana	35.0-72.8	12:1	Day et al. 1973
4	Coastal Lagoon, (Pacific) Mexico	24.6-66.7	11:1	Yanez-Arancibia 1978
6	Coastal Lagoon, Texas	12.1-57.6	10:1	Jones et al. 1963
7	Estuary, South Africa	55.9	9:1	Cowley and Whitfield 2002
8	Estuary, California United States	37.6	6:1	Allen 1982
22	Soft-bottom, California	5.9		Johnson et al. 1994

Comparing the demersal fish densities common to the open-coast, shallow, soft-bottom habitats provides another way of examining the differences between the two habitats and their respective productivities. We used the open coast data collected during the Bight for inner shelf stations located in less than 16 m of water as a proxy for the BMZ habitat (Table 2). Likewise, the reported densities in prior estuarine examples were used. There was a substantial increase in the abundance of fish in the estuaries in comparison to the BMZ habitat. The ratio of these two areas was more than 600:1, estuary:shelf. The ratio of the Magu Lagoon fish count to that of the area near the BMZ was found to be 650:1; and the fish count ratio of the Tijuana Estuary to the BMZ was 9,750:1.

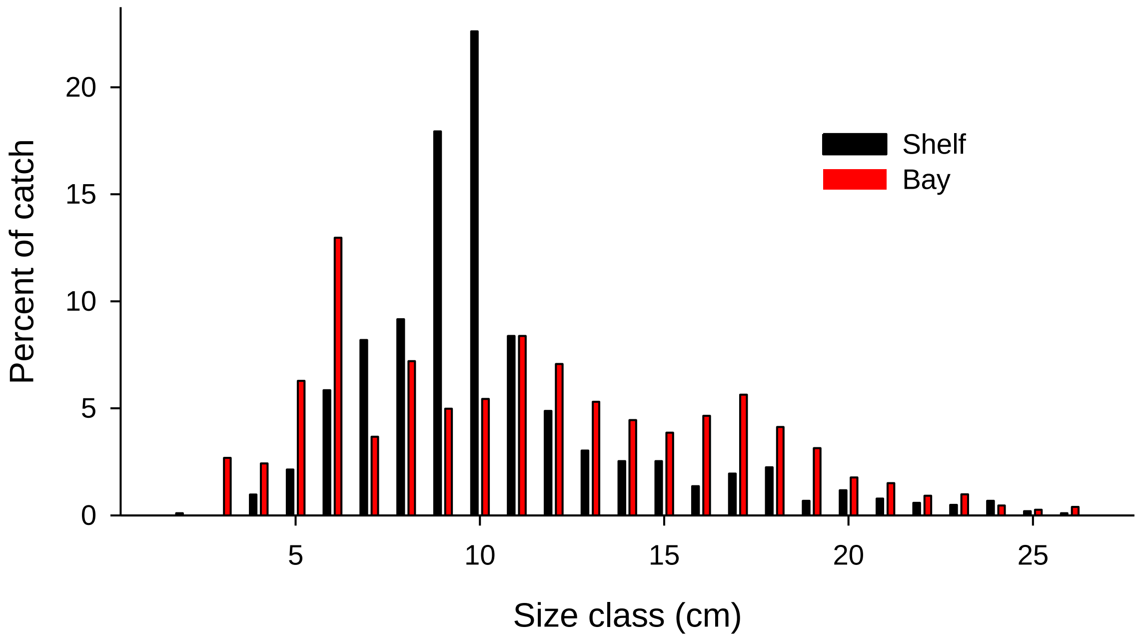

FIGURE 2. PERCENT OF TOTAL MEASURED CATCH FOR ALL FISHES COMBINED REPORTED BY SCCWRP (2016) FOR THE OPEN COAST INNER SHELF STATIONS LESS THAN 16 M DEEP (SHELF) AND IN SOUTHERN CALIFORNIA BAYS (BAY). DATA PRESENTED EXCLUDES SIZE CLASSES LARGER THAN 26 CM.

CONCLUSION

The bottom habitat underlying the BMZ outside the discharge canal is sand. Within the canal, the rocky jetties defining the canal represent higher productivity rocky habitat. Per the OP, this 0.92 acres warrants a 1:1 mitigation ratio. Allis sand, with relatively low infaunal diversity and abundance prior to operation of the CDP. As noted in Table 5, all of the available information comparing habitat productivity supports Poseidon's position that a 10:1 mitigation ratio is appropriate for the soft-bottom sandy habitat impacted by the BMZ, if not conservative. This means 10 acres of impacted soft-bottom habitat would be fully mitigated by the restoration/creation of one acre of wetland/estuarine habitat.

TABLE 5. RATIO OF PRODUCTIVITY OF ESTUARINE HABITAT TO BMZ

Natural Resource	Mitigation Ratio
Vegetation (Net prod. g C/m^2/y)	>10:1[a]
Fish (count/m^2)	650:1 to 9,750:1
Fish Productivity	6:1 to 12:1

a. Since there is no aquatic vegetation present in the BMZ, a true ratio cannot be calculated. However, given the high productivity of the estuarine habitat (1,680 g C/m^2/y) compared to no aquatic vegetation in the BMZ, a ratio of 10:1 is extremely conservative.

Additionally, the values show in Table 5 provide independent validation of Dr. Raimondi's[1] recommendation to the Coastal Commission—that restored estuarine habitat would provide better overall mitigation that would be ten times more productive than a similar area of nearshore ocean waters (excerpt below)—recorded in the California Coastal Commission's Conditions Compliance for the approval of the Marine Life Mitigation Plan (MLMP) for the CDP (See ROWD Appendix R, E-06-013 – Condition of Compliance for Special Condition 8, Poseidon Resources Corporation, Marine Life Mitigation Plan – Page 14 of 18):

> *However, in recognition of the impracticality of creating 55 to 72 acres of offshore open water habitat and recognizing the relatively greater productivity rates per acre of estuarine wetland habitats, Dr. Raimondi suggested that these offshore impacts be "converted" to estuarine mitigation areas. That is, by assuming that successfully restored wetland habitat would be ten times more productive than a similar area of nearshore ocean waters, every ten acres of nearshore impacts could be mitigated by creating or restoring one acre of estuarine habitat. Applying this 10:1 ratio to the nearshore APFs results in 5.5, 6.4, and 7.2 acres, respectively. Although this approach would result in "out of kind" mitigation, it is also expected to produce overall better mitigation – not only is it not practicable to create nearshore, open water habitat, that habitat type is already well-represented along the shoreline, whereas creating or restoring coastal estuarine habitat types would support a long-recognized need to increase the amount of those habitat types in Southern California. (emphasis added).*

Thus, in approving the MLMP, the Coastal Commission found that out-of-kind mitigation consisting of one acre of estuarine habitat creation/restoration for every ten acres of open ocean habitat impacted by the CDP would produce overall better mitigation that would support a long-recognized need to increase the amount of those habitat types in Southern California.

[1] Dr. Raimondi is Professor and Chair of Ecology and Evolutionary Biology at the University of California, Santa Cruz Center for Ocean health, Long Marine Lab. Dr. Raimondi is considered by many to be California's leading expert on entrainment analysis. He has been a key participant and reviewer of most of the entrainment studies done along the California coast during the past two decades, including those done for the Diablo Canyon Nuclear Power Plant, the Huntington Beach Generating Station, Morro Bay Power Plant, Moss Landing Power Plant, and the CDP. He provided independent review of the Coastal Commission's development of the MLMP and the San Diego Water Board's 2009 Water Code 13142.5(b) determination for the CDP. He is also a member of the Coastal Commission's Scientific Advisory Panel (SAP) responsible for determining mitigation needed for the San Onofre Nuclear Generating Station (SONGS) and providing review and oversight for the SONGS mitigation work at San Dieguito Lagoon and review and oversight of the implementation of the CDP MLMP at the Complex.

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