REEF IMPACT MITIGATION: A POLICY FRAMEWORK FOR CALIFORNIA

Capstone Project
University of Washington – Bothell
Masters in Policy Studies

Jason McKinney
June 2013

TABLE OF CONTENTS

List of Tables

List of Figures

LIST OF ACRONYMS AND ABBREVIATIONS

CARP	California Artificial Reef Plan
CCA	California Coastal Act
CCC	California Coastal Commission
CDFW	California Department of Fish and Wildlife
CEMP	California Eelgrass Mitigation Policy
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CSLC	California State Lands Commission
CFR	Code of Federal Register
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
ESA	Endangered Species Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MDFD	Massachusetts Division of Marine Fisheries
NARP	National Artificial Reef Plan
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRI	Natural Reef Indicator
NSFEP	Nearshore Sport Fish Enhancement Program
PAR	Pendleton Arterial Reef
SBC	Southern California Bight
SONGS	San Onofre Nuclear Generation Station
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WDFW	Washington State Department of Fish and Wildlife

1. PURPOSE OF THE STUDY

1.1 Introduction

Natural rocky reefs provide an important habitat function for the marine environment. Rocky reefs are submerged rock outcrops with varying topography that provide habitat for fish, algae including kelp, and invertebrates (NOAA, 2013a). Rocky reefs can be found along the shore in the inter-tidal environment where crashing waves create a turbulent environment. Nearhsore rocky reefs are completely submerged, but where the bottom is within the photic zone, robust algal growth can support a diverse ecosystem. Rocky reefs are beneficial due to the structure that they provide in the aquatic environment, which allows for promotion of benthic (sea bottom) flora and fauna, which supplies the food chain (NOAA, 2013a). Rocky reef habitat plays an important role in the aquatic environment in southern California

Artificial reefs have been used for over 3,000 years to attract fish. The modern concept of an artificial reef use was born in Japan in the 17^{th} century and carried over into the United States in the beginning of the 19^{th} century and then on to Europe in the mid-19^{th} century (Fabi et al, 2011). Artificial reefs have been created in both temperate and tropical waters.

Recently, artificial reefs have been used to mitigate impacts to nature rocky reefs. However, as scientific studies began to gather more information on how artificial reefs perform from an ecological standpoint, questions began to rise regarding the beneficial function of artificial reefs. Scientists were skeptical about the ability of artificial reef to create fully functioning habitat to support and sustain all life cycles of fish and whether artificial reefs merely attract fish from other nearby locations (Bortone, 2006). Much of the current research is hypothesis-based, using experimental designs for artificial reefs to test the hypotheses and create ecological models to determine if the reef meets performance standards (Bortone, 2006). This is true for both creating artificial reefs for fish enhancement, as well as their use for mitigation of impacts associated with development. Due to the uncertainty with the ecological performance of artificial reefs, some governments do not allow their use for fisheries enhancement or as mitigation for reef degradation (Palsson et al, 1998 and Guam, 2009).

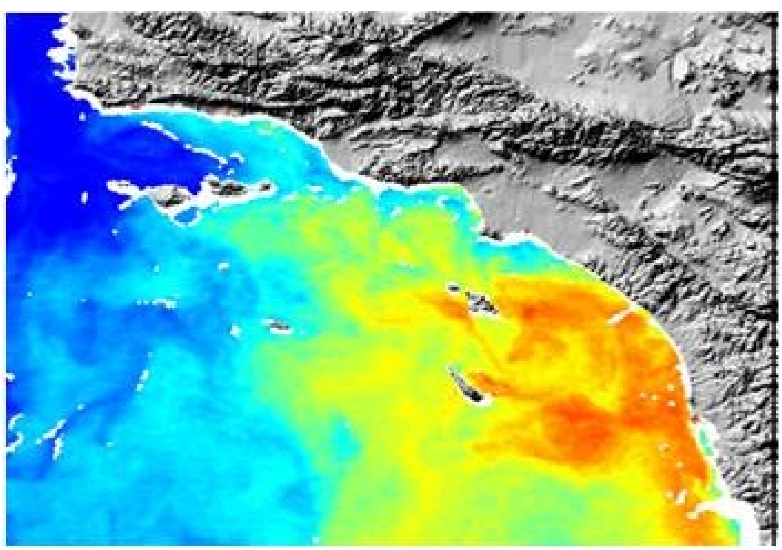
Rocky Reefs in California

California has rocky reefs throughout its coastline and offshore areas. The Southern California Bight (SCB) is a very unique ecosystem where cool temperate waters from the north converge with warm temperate waters from the south. The SCB covers a geographic area beginning from Point Conception in the north, to the Mexican border in the south (see site map in Figure 1 below).

Figure 1 – Area of the Southern California Bight (SBC)

Source: http://www.oceanconservation.org/research/pastladp.htm

Figure 2 – Satellite Image of Ocean Currents Mixing in the SBC



Source: http://www.sccwrp.org/ResearchAreas/RegionalMonitoring/BightRegionalMonitoring.aspx

A comprehensive survey of rocky reefs of the SBC conducted in 2008 by the Southern California Coastal Water Research Project (Pondella et. al., 2011) found the region contains 120 separate rocky reefs covering over 186 square miles (46%) of the region's coast line. Rocky reef are much more prevalent along offshore islands where they comprise 75% of the coastline, compared with only 25% of the coastline along the mainland. The survey classified the reefs into six categories: low relief and cobble, flat reefs, middle relief, high relief, wall reefs, and pinnacles. The area along the mainland was found to be comprised mainly of low relief reefs, which are more susceptible to stressors such as burial from siltation (Pondella et al, 2011).

Human populations and associated development is much more prevalent along the mainland coast where there is limited availability of rocky reefs (CCKA, 2008 and Seaman, 2007). This makes the potential for loss or degradation of rocky reefs from development impacts a significant concern. Although there is the potential to mitigate losses of ecological function in reef habitats (NOAA, 2007), the state of California does not have a formal policy in place to guide the design, emplacement or monitoring of reef habitat mitigation projects.

The need for a formal policy has become apparent with the development of an artificial reef as mitigation for the San Onofre Nuclear Generation Station (SONGS). The reef was a result of mitigation required by the California Coastal Commission (CCC) to offset impacts to kelp forest habitat (Reed et al, 2005). The CCC is authorized to require mitigation for projects that impact coastal resources through the California Coastal Act; however, no formal policy exists to implement the law. A more recent development is the potential use of an artificial reef by the Port of Los Angeles as part of their proposed mitigation bank (Anchor QEA, 2012).

However, there have been few cases where the emplacement of artificial reefs has been the sole method for mitigation of impacts to natural rocky reef habitat. This has created uncertainty for regulators who need to determine if artificial reefs can be used to compensate for loss of aquatic habitat as required under the Clean Water Act (CWA) and the California Coastal Act (CCA). A reef mitigation policy will help guide the development of future artificial reef development in a way that provides more consistency than currently exists today.

1.2 Statement of Purpose

The purpose of this capstone project is to analyze an appropriate policy framework to address impacts to natural rocky reefs, and if compensatory mitigation is decided as the appropriate means, provide guidance for site selection, monitoring and adaptive management of artificial reef mitigation projects.

As mentioned above, there is currently a lot of uncertainty when it comes to predicting the value and success of reef mitigation throughout the U. S., especially as it applies to rocky reef habitat similar to that found in Southern California. Only a limited number of artificial reef projects have been developed in the U.S. for the purpose of compensatory mitigation. Based on existing literature, most of those projects have occurred as mitigation projects for coral reefs (USFWS, 2004). Several methods have been established to determine how effective artificial reef projects are in meeting their performance objectives but no standard methodology has been universally accepted. Mitigation projects typically fail to meet their performance objectives due to poor site selection, reef design, or a lack of clear performance standards or monitoring protocols. Poor site selection can result when siting decisions are only based on physical measures (Barber et. al., 2009).

Site selection is typically based on physical variables meant to avoid potential obstacles, such as shipping channels and commercial fishing areas and most of the scientific effort is placed on post-installation monitoring. This approach to site selection, while important to determine the effectiveness of each site, does not provide artificial reef planners with the information needed to make informed site selection decisions for future artificial reef projects, because it does not account for biological measures such as substrate type which could affect the function of the reef (Hueckel et. al., 1989 and Barber et. al., 2009a).

While there is uncertainty, there are still several artificial reef development plans and policies that exist in the U.S. and throughout the world specifically for economic benefit of fish production (i.e., building reefs to accommodate habitat to attract specific fish species) as well as preservation or enhancement of coastal habitat (Wilson et al 1990, FFWC 2003, NOAA 2007, Reynolds, 2007 and Rousseau, 2008). These plans can be useful as a starting point for the development of policy specific to rocky reef degradation mitigation. However, these plans and the tools contained within them will need to be modified in order to address the specific goal of creating habitat to mitigate the impacts of habitat loss.

This capstone will evaluate potential objectives for a rocky reef development policy framework. This should provide a valuable service for future policy development for addressing impacts to natural reefs. There are no policies in the State of California that specifically address procedures to mitigation for impacts to natural reefs or the, siting criteria, design requirements, or performance measures for artificial reefs constructed as mitigation.

The objectives for this capstone research project can be summarized as follows:

1. Outline a regulatory framework for the state of California meant to guide mitigation for loss of reef habitat and degradation of reef ecological function.
2. Discuss relevant components a reef mitigation policy would need in order to provide a higher likelihood of success for a reef mitigation project.

2. REVIEW OF LITERATURE

This section describes what reef habitats are and the threats they face. This section also describes existing laws, regulations, policies, plans, and tools that have been developed to provide more certainty that mitigation required by regulatory agencies to offset permitted impacts on reef habitat meet the goal of "no net-loss" of function.

2.1 Reef Habitat

Rocky reefs provide key structure for an abundance of marine life . Rocky reefs provide structure such as crevices and passageways for fish to move about with protection and provide surfaces for a host of smaller organisms such as invertebrates and aquatic vegetation (NOAA, 2013a). Rocky reef habitat in the nearshore environment provides even more abundant flora and fauna the off-shore reef due to availability of sunlight and mixing from wave action. In California, rocky reef habitat supports giant kelp forests by providing a hard surface to anchor to. Kelp are vital to a healthy ecosystem. The giant kelp forests support various life stages for over 800 organisms. Up to 80% of California's giant kelp forests have disappeared in the last 100 years from both natural and anthropogenic causes (CCKA, 2008). This loss of kelp forest habitat makes it vital that future impacts to rocky reef habitat (the foundation for giant kelp forests) are either avoided or properly mitigated to replace the loss of natural ecological function.

Reefs have been studied extensively in Southern California by many agencies and organizations. Most recently an effort was undertaken by the Southern California Bight Regional Monitoring Program in 2008 with three main goals of understanding the distribution of hard bottom surfaces, documenting their range of biological condition in relation to species assemblages, and understanding how these conditions are affected by human factors (Pondella et al, 2012).

The survey documented kelp at each of the 120 sites that were observed. The survey documents seventy-eight fish species with fish biomass at some reefs appearing similar to that of protected reef areas. The study also documented urchin barrens at 38% of the reefs as well as indications of impacts due to fishing pressure. However, a direct correlation between fishing pressure and fish abundance could not be made without better assessment tools (Pondella et al., 2011).

2.2 Potential Threats

Natural reefs in California suffer from the effects of both natural and anthropogenic stressors. Natural effects include El Nino events that cause larger than normal storms in southern California. These large events can shift sand and bury reefs. Predation by certain species such as sea urchins is also an issue. Sea urchins eat young kelp, causing a stunting in the development of mature giant kelp forests.

Due to proximity to a growing human population, these reefs are also under a variety of anthropogenic stressors (e.g. turbidity, river plumes, sedimentation, overfishing, pollution, and dredging) and harmful algal blooms (CCKA, 2008 and Seaman, 2007). In southern California, reefs are also threatened from many coastal power plants that withdraw large volumes of water for cooling and release heated water back out into the ocean. The influx of warm water back into the ocean can have a negative impact on the ecosystem, including reef habitats near the location of the release site (Reed et. al., 2012). California is looking into the development of desalinization plants as an alternative source of freshwater. Desalinization plants release brine water back into the ocean that can change salinity levels that may kill sensitive reef organisms (NMFS 2013a). There are also several large port facilities in the SBC that anticipate infrastructure improvements and maintenance that could impact the aquatic environment, including rock reef structures (POLA 2012 and POLB 2006).

2.3 Artificial Reefs as Mitigation

The concept of using artificial reefs to offset the impacts to natural reefs by authorized projects is relatively new. Only in the last few decades have artificial reefs been used as a mitigation strategy to offset impacts to giant kelp forest habitat (Reed et al. 2006) and oyster reefs (Loftus and Stone, 2007). The majority of reef mitigation projects have occurred in tropical waters associated with coral reef habitat. However, rocky reef mitigation projects have occurred in Alaska, Washington, and California along the Pacific coast, as well as Massachusetts and Delaware on the Atlantic coast. The majority of these projects have been pilot projects which serve as mitigation, but also serve as experiments to better understand the complexity of creating an artificial reef that will meet habitat creation goals set forth as permit conditions.

Various methodologies have been developed to assist with artificial reef development. A site selection model using seven systematic variables to assess performance was developed in Massachusetts. Reefs developed from this approach were found to have an overall greater abundance of organisms when compared with natural reefs, but less species diversity. This was thought to be the result of the retarded ability of sessile or slower moving species' to travel to and colonize the new reefs (Barber et al., 2009a).

Jesse et al. (1985) conducted a study of fish densities in Southern California among two natural areas and one artificial reef. They found that that fish densities were indistinguishable between that natural and artificial reef. They further concluded that fish densities could be attributed to reef design (steep slopes) and proximity to other natural reefs. A study by Reed et al. (2006) in the same region was conducted to examine various types of substrate used to create artificial reefs. The results of the study indicate that kelp forest will establish on many types of substrate, but the surface area of rocky reef substrate was the key factor in determining densities of fish.

Both studies above use fish populations as an indicator for artificial reef success. However, when using artificial reefs as mitigation, all ecological functions should be considered. Only by understanding the entire suite of ecological services a natural reef provides can a more holistic set of criteria for artificial reef success be established. Using a more holistic set of criteria could provide a more accurate prediction regarding organisms, population and reef characteristics as well as techniques for testing predictions of success for future artificial reef sites to meet their objectives (Miller, 2002).

2.4 Regulatory Overview

Impacts to the aquatic environment are regulated by several federal, state, and in some cases, local permitting processes in California. The discussion below highlights the regulations that are relevant to mitigation for the impacts to the aquatic environment (including to reefs).

2.4.1 Federal Regulations

Clean Water Act - The Clean Water Act (CWA) was originally enacted in 1948 as the Federal Water Pollution Control Act in 1948. Major revisions in 1972 gave the act its common name, CWA that is recognized today. The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters (USEPA 2013a). The U.S. Environmental Protection Agency (EPA) has statutory authority to regulate discharge under Section 401 of the Act (33 U.S.C. 1251 et seq.) and the U. S. Army Corps of Engineers (USACE) has authority to permit dredging and filling within navigable waters of the United States under section 404 of the Act (33 U.S.C. 1251 et seq.). The CWA also maintains provisions for the USACE to require mitigation for impacts to natural habitats as described in 33 CFR Part 332 (2008).

Rivers and Harbor Act of 1899 - Section 10 of the Rivers and Harbors Act gives the USACE statutory authority to regulate and permit activities that may affect navigation within waters of the U.S. The USACE reviews and can authorize projects that propose to place obstructions within the areas of navigation. This would include the placement of artificial reefs (USEPA 2013b).

Coastal Zone Management Act of 1972 (CZMA) - The CZMA was enacted by congress to "preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations" (16 U.S.C. § 1452, Sect 303). The Act is administered by NOAA, but authority is delegated to each state by mandating they prepare coastal zone management programs to balance ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development within the coastal zone (NOAA 2013b).

Endangered Special Act of 1973 as amended (ESA) – The ESA was enacted by congress to conserve ecosystems from which species that are considered "endangered" depend. The ESA requires federal agencies that fund, permit, or carry out activities that may affect a species listed as threatened or endangered under the ESA to consult with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) under Section 7 of the ESA. The goal of the consultation process is to ensure a federal action does not jeopardize the continued existence of an ESA-listed species (USEPA 2013c).

Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) – The MSFCMA (Public Law 94-265, as amended), mandates the use of annual catch limits and accountability measures to end overfishing, provides for widespread market-based fishery management through limited access privilege programs, and calls for increased international cooperation. The MSFCMA also has a provision for the conservation of "essential fish habitat" which is habitat necessary for fish to spawn, breed, feed or grow to maturity. Rocky reefs are considered rocky reef habitat and projects that may impact rocky reefs need to consult with NOAA to determine if the project will affect essential fish habitat (NMFS, 2013b).

National Artificial Reef Program (NARP)

The National Fishing Enhancement Act of 1984 was developed in order to coordinate and promote information on artificial reef development among coastal state resource agencies. The Act gives NOAA and the Army Corps of Engineers (USACE) lead responsibilities to encourage, regulate, and monitor development of artificial reefs in the navigable waters and waters overlying the outer continental shelf of the United States. NOAA is responsible for the Plan, which provides guidance on reef development. The USACE is responsible for permitting the artificial reef project, including the provisions of 33 CFR Part 332 regarding compensatory mitigation (NOAA 2007).

NOAA developed an initial National Artificial Reef Plan (NARP) in 1985 and then revised the plan in 2007. The NARP has a main goal of standardizing information used by federal, state, and local agencies to site and permit artificial reef projects. The NARP was designed with a focus towards fisheries enhancement by providing guidelines for artificial reef deployment and providing a federal funding mechanism to provide grants to state agencies to help off-set the costs of artificial reef development. The NARP but also provides brief information on how artificial reefs could serve as a broader tool to restore ecological function, not just fish enhancement. The NARP was amended in 2007 in part to acknowledge the increased emphasis in recent years to develop artificial reef for non-extractive activities, such as habitat improvement (NOAA 2007).

2.4.2 State of California Regulations

California Coastal Act - The California Coastal Act (CCA; Public Records Code (PRC) Division 20 Section 30001 states that California's coastal zone is a valuable resource that should be protected to balance human use and ecological function. California's coastal zone generally extends from 1,000 yards inland from the mean high tide line and 3 nautical miles seaward of the mean high tide (NOAA, 2012). The CCA also empowers the California Conservation Commission (CCC) to carry out these mandates and establish mitigation requirements. In 1972 the California legislature passed the Coastal Act, which implemented the federal Coastal Zone Management Act. The CCA also provides harbor districts with the responsibility to protect and improve the quality of the marine habitat.

In addition, the CCA gives the state of California the authority to require and enforce compensatory mitigation for impacts to the coastal zone, even if the impact does not meet the threshold for the USACE and EPA (CRPC 30800-30824) enforce conditions of development permits issued under the CCA (CPRC 30800-30824).

California Marine Life Protection Act (MLPA)

The MLPA was passed in 1999. The MLPA requires the California Department of Fish and Wildlife (CDFW) to reevaluate existing marine protection areas (MPA) and potentially designate new MPAs. To carry out this evaluation, the state of California was broken out into five sub-regions, including the SCB. The state created the MLPA Initiative which is a public-private partnership to bring together a variety of stakeholders to develop management plans for each region (CDFW 2013a).

While the MLPA does not directly regulate artificial reef development, it could be used as a vehicle for coordinating future artificial reef projects. The data on marine ecosystems that is being collected as part of the effort could be incorporated into the site selection process for new artificial reef projects.

California Environmental Quality Act (CEQA)

CEQA requires state and local agencies to identify potential project impacts in the environmental and provide avoidance or mitigation for those impacts. CEQA generally follows a similar process with that of the National Environmental Policy Act (NEPA). However, NEPA does not have a statutory requirement for mitigation while CEQA does (CNRA 2013).

Public Trust Doctrine

The Public Trust Doctrine, which includes common law principals that guide the use of public trust lands, is administrated by the California State Lands Commission (CSLC). The Public Trust Doctrine stipulates that tidelands and lands under navigable waterways are a public resource and should be available for public use (CSLC, 2001). Approval must be granted by the CSLC before development, including deployment of artificial reefs, can occur upon the lands. .

The CSLC (2007) can grant permission as long as the project meets the following criteria:

- The primary use must be water related or water-dependant
- It directly supports or promotes uses authorized by the Public Trust Doctrine
- The use must accommodate or enhance the statewide public's enjoyment or benefit, not just a local agency

California Endangered Species Act (CESA)

The CESA provides protection for all native species of fish, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats that are either threatened with extinction of experiencing significant decline. The CDFW is the lead agency in charge of enforcing the CESA and is authorized to issue "incidental take" permits if a project may affect a species, but the effect is minor and will not lead to degradation of that species (California Fish and Game Code, Section 2053).

2.5 Policy Frameworks in the United States

The previous section described the laws that govern impacts to reef habitat. This section describes relevant policies and procedures that have been developed to implement the laws.

The USEPA and the USACE issued revised regulations (Final Rule) governing compensatory mitigation for impacts to waters of the United States under Section 404 of the

Clean Water Act on March 31, 2008 Code of Federal Register (CFR) parts 325 and 332 (eCFR 2010a, 2010b).

The Final Rule identifies components that need to be included within a mitigation plan. 33 CFR 332.4(c) outlines twelve components. The twelve fundamental components include: objectives, site selection criteria, site protection instruments (e.g., conservation easements), baseline information for both impact and mitigation sites, credit determination methodology, a mitigation work plan, a maintenance plan, ecological performance standards, monitoring requirements, a long-term management plan (LTMP), an adaptive management plan, and financial assurances (eCFR 2010a, 2010b). However, the Final Rule does not provide guidance for how each of the components of a mitigation project should be implemented.

Several states have developed artificial reef programs based on the NARP, especially in the tropical environments relating to coral reef habitat. These plans emphasize fish production for the enhancement of recreational fisheries. Some plans also make reference to the potential for use of artificial reefs in mitigation, but caution their use until additional scientific information is gathered to confirm their ability to provide habitat value (Bentivoglio 2003).

The Massachusetts Division of Marine Fisheries (MDMF) suggests that mitigation for lost habitat function through the use of artificial reef development remains a controversial issue because success can't be determined for some projects due to the lack of funding for monitoring (Rousseau, 2008). North Carolina allows the use of artificial reefs as mitigation only to replace damage to natural reef habitat and only when it can be demonstrated that the artificial reef will provide the same or more ecological benefit as the natural system (NCDNR&CD, 1998). The State of Florida has an extensive artificial reef program. Florida's artificial reef program goals include providing economic and recreational opportunities as well as scientific study, but the program does not include specific guidance or requirements for using artificial reefs to mitigate for impacts to natural reef habitat (FFWC, 2003).

While some states allow artificial reef development as a mitigation option, there are other states and U.S. Territories that either discourage or do not allow artificial reefs to be developed. The State of Washington developed several artificial reefs in the 1980's and 1990's for the purpose of fisheries enhancement. However, this practice was suspended as documented in the Washington State Department of Fish and Wildlife (WDFW) Puget Sound Ground Fish Management Plan (1998) where WDFW states "Until the benefits of artificial reefs in Puget Sound can clearly be demonstrated, artificial reefs should not be used in the context of the current Artificial Reef Policy to enhance fisheries for groundfish. Artificial reefs may act as a population and habitat enhancement technique when used in the context of a permanent no-take refuge, but only if their benefits do not negatively affect other marine organisms". The development of artificial reefs (either for fish production or habitat production) has ceased in the state of Washington.

Oregon has developed the Oregon Territorial Sea Plan (2013) with the concept of identifying critical habitat, including rocky reefs. The plan also acknowledges future infrastructure that could be developed along and in the coastal waters, particularly in association with other alternative energy development. The results of studies based on the Territorial Sea Plan exclude areas with rocky reef habitat from being developed. This approach is intended to circumvent the need to develop rocky reef mitigation projects (Pers. Comm. Krutzikowsky, 2013).

The U.S. Territory of Guam has a comprehensive mitigation plan to guide and evaluate potential mitigation projects in order to provide no net loss of aquatic habitat. The mitigation policy explicitly states that artificial reefs developed for the purpose to replace loss of habitat is not supported (GCMP 2009).

Massachusetts Artificial Reef Plan

Massachusetts has developed four artificial reefs beginning in 1978. These reefs were developed independently with no state policy to guide the permit agencies or process. Massachusetts has projected an increase in demand for artificial reefs from various user groups, conservationists, and government agencies. In order to prepare for the projected increase in artificial reef development, Massachusetts has developed a plan to address reef design, placement, monitoring and management. The plan is managed by the Massachusetts Department of Marine Fisheries (MDMF) (Rousseau 2008).

The plan was developed under the NARP and identifies key features necessary for establishing an effective plan including: coordination, site selection, materials, maintenance and long-term monitoring. The goal of this plan is not only to enhance fisheries, but also to establish policies to ensure future reef developments meet resource protection needs. This plan acknowledges artificial reefs can be used for mitigation and suggests the plan should be used to guide those mitigation projects. However, the plan also acknowledges that each proposed artificial reef project needs to be reviewed to ensure it has clear goals and minimizes conflicts with other user groups (Rousseau, 2008).

To supplement the policy, Massachusetts is also preparing a statewide site selection model to help coordinate the location of future reef projects to avoid user conflicts (MDMF, 2013). The particular focus of the statewide model is for fisheries enhancement, but could also be used a tool for mitigation site selection.

Pilot Projects

Several states have developed artificial reefs as pilot projects to study the potential of artificial reefs for use in future mitigation projects, without a formal reef mitigation policy in place.

An artificial reef was created in Puget Sound in 1987 to offset impacts to a nearshore reef. The site consisted of small rocks (0.15 to 1.2 meters) placed over sand and mud substrate. Natural Reef Indicator (NRI) species were used as the metrics to compare the reef performance with that of natural reefs. NRI species consist of economically important fish, but does not account for other species. The reef was found to have achieved the desired recruitment of NRI species within the first eight months of construction (Hueckel et al., 1989). However, additional studies would have been needed, to determine if this was due to fish attraction or additional fish production.

Alaska's first artificial reef was deployed in 2006 in Whittier, approximately an hour and a half drive southeast of Anchorage. Two natural reefs and one area of hard bottom located nearby were used as reference sites. After the first year of monitoring the artificial reef exhibited a diverse fish community. The study concluded after two years of monitoring that the artificial reef and natural reefs provide similar fish communities. The study goes on to note that continued surveys will be needed in order to document the temporal and spatial changes to reef communities (Reynolds 2007).

2.6 California's Approach to Artificial Reefs

California started developing artificial reefs with a pilot study in 1958 to determine if artificial reefs could provide improved habitat and recreational fishing opportunities. The pilot study included developing three artificial reefs using "materials of opportunity" including streetcars. These early experiments did prove that fish densities increased around the reefs. There was even some new, but temporary growth of kelp forest (Wilson et al., 1990).

The next two decades saw further experimentation and study into reef design and placements in order to study species recruitment and densities. In 1980 Southern California Edison decided to construct a coastal nuclear power facility in northern San Diego County. An impact of the power plant operations would be the release of warm cooling water that could impact nearby kelp forests. This led Southern California Edison to enter into an agreement with the California Department of Fish and Game, now Department of Fish and

Wildlife (CDFW) to develop the Pendleton Artificial Reef (PAR) to further study the potential use of artificial reefs as mitigation (Wilson et al., 1990). This project led the California Department of Fish and Game to shift their emphasis in artificial reef development from attracting and holding fish to enhancing fish and invertebrate stocks. The CDFW also shifted emphasis from attracting to holding fish, leading to the creation of the Nearshore Sport Fish Enhancement Program (NSFEP) (Wilson et al., 1990 and Bedford, 1992). The NSFEP is a program designed to improve sport fishing opportunities by creating or enhancing habitat (Lewis and McKee, 1989).

In 1985, the California legislature formally recognized the CDFW as the lead agency for California's reef building process. The legislation also required the development of long-term plans for improving nearshore fisheries production. In 1990 CDFW issued the California Artificial Reef Plan (CARP) for Sport Fish Enhancement (Wilson et al., 1990). While this plan does focus on fish production for recreational consumption, it also acknowledges mitigation as a potential use of artificial reefs. The plan itself is fairly brief and has not been updated since 1990.

As mentioned previously, while California has been developing artificial reefs since the 1950's to enhance fish production, only a few have been developed for mitigation purposes. In fact, all three artificial reef projects developed as mitigation are all related to the SONGS project. Two were developed as pilot studies to identify methods of placement, design, and monitoring that would provide the highest likelihood of success. The results of the first two projects culminated into the North Wheeler Reef which was constructed in 2008 to address permit conditions set forth by the CCC. In order to fulfill the permit obligations, the reef must become fully functional (meeting all performance criteria) for 30 years.

2.7 Other Applicable Mitigation Policy Tools in the United States

Draft Eelgrass Mitigation Plan

The Southwest Region of the National Marine Fisheries Service (NMFS) has prepared the draft California Eelgrass Mitigation Policy (CEMP) for the state of California. While this policy is not related to reef mitigation, it serves as an example of developing new policy for mitigation of damage to a specific habitat type in California and where there is limited scientific information supporting the implementation. The draft CEMP has been developed to establish a coordinated implementation of eelgrass mitigation for the entire state of California (NMFS 2011).

NMFS implemented a Habitat Protection Policy (1991) that stated the Southwest Region NMFS "will not recommend approval or authorization of any project or activity that will damage any existing or potentially restorable habitat of living marine, estuarine, or anadromous resources". This policy reinforces the need for mitigation if a project cannot avoid impacts to those mentioned resources. The policy further describes a preferred sequence to mitigation with on-site mitigation the most preferred. This approach is consistent with the 2008 Final Mitigation Policy (USACE 2008a).

The first issue that NMF's draft policy attempts to address is a lack of a coordinated effort. Prior to the draft Policy there was no specific eelgrass mitigation policy in northern and central California. There was a formal policy developed specific to Southern California. The policy in Southern California was used to guide mitigation development in Central and Northern California, but the policy was not always compatible because it only considered the unique ecological system of Southern California (NOAA 2011).

The draft mitigation policy also acknowledges the differences in eelgrass habitats among the various regions along the California coastline. The draft policy is broad enough to cover the entire state, but also provides measures and guidance depending upon where the mitigation is to occur (northern, central or southern California). This approach to regional flexibility will be further addressed in Section 4 below.

3. RESEARCH DESIGN

3.1 Explanation of Approach

There is a need to develop a reef degradation mitigation framework for the Southern California Bight (SBC). A primary objective of this capstone project is to outline a policy framework for the mitigation of impacts to natural rocky reef habitat. The policy framework will be evaluated to determine whether it should just apply to the SBC or if the policy framework could be applicable throughout the coast of California.

In order to develop a policy framework, this capstone incorporates a literature review, interviews and case studies. Information gathered from the literature review and case studies are used to develop key elements to be included within a reef mitigation policy developed from the policy framework. Information gathered from interviews with staff from the California Coastal Commission and the Oregon Department of Fish and Wildlife were used to confirm their agencies' current approaches to mitigating the impacts to natural rocky reefs as well as their capacity to implement new policy.

4. ANALYSIS AND RECOMMENDATIONS

4.1 Policy Framework Objectives

Chapter 2 describes the gaps in existing data to demonstrate the effectiveness of existing artificial reefs to provide offsetting habitat function for impacts to natural rocky reefs. However, future impacts to natural rocky reefs are expected to occur; therefore a policy framework in California is needed. In order to develop a policy framework to address impacts to natural reef habitat, key objectives need to be identified. This capstone examines five key policy objectives. The objectives include; Establishing a Lead Agency, Legislative Scope, Geographic Scope, and Approach to Compensatory Mitigation

4.1.1 Establish a Lead Agency

Establishing a Lead Agency is critical because several state and federal agencies currently have over-lapping jurisdiction when it comes to impacts to the aquatic environment. This can make it confusing for the permit applicant that may be giving conflicting information and guidance by the various agencies involved. The California Coastal Commission (CCC) and the California Department of Fish and Wildlife (CDFW) have jurisdiction over major components of the permit process and could require mitigation for impacts to natural rocky reefs.

4.1.2 Legislative Scope

The legislative scope refers to the need for either a brand new policy to be created and implemented or an existing policy that could be modified to regulate the reef mitigation process. Based on literature review, the California Artificial Reef Plan could serve as an existing policy with the potential to be expanded in scope to incorporate provisions to regulate the creation of artificial reefs for the purpose of mitigation.

4.1.2.1 *Expansion of the Existing Artificial Reef Plan*

The CDFW administers California's Artificial Reef Plan. The current plan provides guidance for developing artificial reef structures for fisheries enhancement, but not mitigation. The plan has not been updated since 1990 nor has the CDFW recently actively pursued the development of artificial reefs (Engel pers. comm., 2013). The science on artificial reef function has evolved significantly since 1990 so this policy will need to be updated to incorporate the latest science and understanding for artificial reef development. Specifically, it should incorporate insights gained from the SONGS project.

4.1.2.2 *New Reef Mitigation Policy*

The second policy option would create a new mitigation policy focused solely on artificial reef development for the purposes of habitat creation, similar to the eelgrass mitigation policy developed by NMFS in southern California. This policy would be independent of the existing artificial reef plan's purpose of enhancing sport fishing.

4.1.3 Geographic Scope

The geographic scope is the area of California coastal waters the policy will cover. As discussed previously, the Southern California Bight has a unique ecosystem created by the mixing of sub-tropical waters from the south and cooler temperate waters from the north. The SBC is different than the temperate waters of the rest of the coast of California north of Point Conception. This analysis will determine if the policy should only cover the SBC, or if the policy should be expanded to cover all California coastal waters.

4.1.4 Approach for Compensatory Mitigation

The USACE mandates that the hierarchy of mitigation is to first avoid the impact. If the impact cannot be avoided, then the project must attempt to reasonably reduce the impacts. Once all reasonable avoidance and measures to reduce impacts have been implemented, only then can compensatory mitigation be used. Compensatory mitigation is the creation of habitat to offset the loss of habitat by the project (USACE, 2008a).

There are currently three primary approaches for implementing compensatory mitigation. They include mitigation banks, in-lieu fee or permittee-responsible. Each type is allowed by the USACE. However, the USACE has stated a preference for mitigation banks first, in-lieu fee second and permittee-respond third (USACE, 2008a).

4.1.4.1 *Mitigation Banking*

According to the USACE (2013a) a mitigation bank is "A mitigation bank is a wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or in certain circumstances, preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 or a similar state or local wetland regulation. A mitigation bank may be created when a government agency, corporation, nonprofit organization, or other entity undertakes these activities under a formal agreement with a regulatory agency". The operator of the mitigation bank, once approved, is responsible for construction, maintenance and long-term management of the site. A permittee typically pays a fee to a third party operator of a mitigation bank. The fees are based off of established credits from the bank. Credits are typically a function of area (acres) and quality of habitat type created.

Because of the economies of scale with the typical creation of one large site; a mitigation bank provides a greater ecological benefit, versus several smaller individual sites that are associated with permit-responsible mitigation. Mitigation banks are limited in their ecological value by their location within a service area. A service area establishes the area, such as a watershed of where the mitigation bank provides a benefit. The service area also establishes the limits of where permittee can purchase credits. A permittee cannot purchase credits from a mitigation bank unless the impacts from their project occur within the mitigation bank's service area (USACE, 2013a).

Mitigation banking has been under way in California since 1995. In 2011 the State of California and several federal agencies renewed a memorandum of understanding for the purpose of jointly establishing a policy framework to coordinate the development and management of mitigation banks in the state (California Fish and Game Code 1797). There are currently 41 mitigation banks established under California's program and 75 total approved by the USACE (CDFW 2012, USACE 2013b). None of the mitigation banks have been developed for artificial reef habitat. The Port of Los Angeles has proposed to create an artificial reef habitat for the purposes of a mitigation bank, but it is only in the planning stages at this time (Anchor QEA, 2012).

4.1.4.2 *In-Lieu Fee*

The USACE (2013a) states that an In-lieu Fee program is an approach to mitigation where a "permittee pays a fee to a third party in-lieu of conducting project-specific mitigation or buying credits from a mitigation bank. In-lieu fee mitigation is used mainly to compensate for minor impacts to wetlands and other aquatic resources when better approaches to compensation are not available, practicable, or when the use of an in-lieu fee (ILF) program is in the best interest of the environment and watershed". Fees are paid to a third-party by the permittee. The third-party typically holds these fees in trust until enough fees are collected to construct a mitigation site. Like a mitigation bank, an in-lieu fee program also has a service area that defines geographic limits of where credits can be purchased (USACE, 2013a).

4.1.4.3 *Permittee Responsible Mitigation*

This mitigation approach includes the restoration, establishment, enhancement, or preservation of habitat by a permittee for the loss of habitat from their specific project. This form of mitigation is typically approved for project impacts in areas where no mitigation bank or in-lieu fee program exists. This type of mitigation puts the burden on the permittee to ensure long-term success of the mitigation.

4.2 Policy Framework Analysis

To evaluate the elements of a policy framework, four criteria were developed in order to provide an objective evaluation. There are no universally accepted criteria for evaluating environmental policy (Burger et al., 2009). The criteria were developed from lessons learned during the literature review and include the following:

1. **Institutional Constraints** – Refers to the ability of the agency to full carry out the objective.
2. **Regulatory Costs** – Anticipated cost incurred by the agency and permittee to carry out the objectives.
3. **Stakeholder Support**– Stakeholder are any and all groups or persons who either actively consume or benefit from reef resources, such as fishermen or people seeking permits to impact reefs. Consumption can be in the form of taking fish or passively enjoying the intrinsic value of the reef through SCUBA diving or other passive

activities. This criterion is used to gauge how the policy objective may viewed by these various user groups.

4. **Effectiveness** – The degree to which the policy element will lead to the over-all objective of no net loss of ecosystem function.

4.2.1 Establish a Lead Agency to Implement the Policy

The California Coastal Commission (CCC) and the California Department of Fish and Wildlife (CDFW) are each plausible agencies to lead a new reef mitigation policy. Each agency has a strong role in the permit process, including a focus towards habitat impacts.

4.2.1.1 *Institutional Constraints*

Both agencies are governed by a commission. Members of both commissions are political appointments. The CCC is governed by a commission of 12 voting members. Four members are appointed each by the Governor, Senate Rules Committee and the Speaker of the Assembly (CCC 2013). The CDFW is governed by a commission of up to five members who are all appointed by the governor and affirmed by the senate (CFGC 2013). As both agencies answer to a commission, it can be assumed that both agencies may operate under a similar political environment. Each agency also has regulations that determine their authority.

As previously mentioned, the CCC has authority to grant or deny development projects within the California coastal environment (from 1,000 yards inland to 3 miles offshore). The CCC also has the authority to enforce conditions set in its permits. Enforcement is vital to ensure there is a mechanism in place for recourse if a mitigation site were not to meet its performance standards.

The CDFW has a more limited authority to regulate impacts to natural reefs or determine compensatory mitigation when compared to the CCC. The Marine Life Protection Act authorized the CDFW to evaluate and determine marine protected areas. The CDFW has just completed its process to designate these protected areas. These areas include both natural and some artificial reef habitat. The California Endangered Species Act (CESA) also provides authority for the CDFW to evaluate projects based on their potential to impact state-listed endangered or threatened species. The CESA species has a limited scope and does not cover all potential species that may be affected by impacts to natural rocky reef habitat. However, due to CDFW's involvement as the lead state agency for California's mitigation banking program, CDFW could play a role if mitigation banking or in-lieu fee programs are implemented as part of compensatory mitigation which is analyzed further below.

Also at issue are the goals and authority of CDFW. The CDFW is directed to protect fish and wildlife as well as their habitat per the California Fish and Game Code, Division 2, Chapter 6. Fish and their habitat is an integral component of a healthy reef system. However, as demonstrated with the SONG's project; the CCC's permit process triggered the need for compensatory mitigation. While the CDFW is an agency with a more demonstrative role with active marine resource protection as demonstrated through the mandates of the MLPA, its permit authority may not capture all projects that could impact natural reef habitat.

4.2.1.2 *Regulatory Cost*

Establishing a lead agency is expected to have a similar effect for either the CCC or the CDFW. Both agencies already have programs in place to permit project and monitor projects. However, an inadequate level of agency staffing could be an issue and might result in the need to hire more staff (Engel pers. comm., 2013). Due to on-going budget issues in the state of California and severe cuts to state agencies, even small increases in cost to implement and run the program could severely burden the state agency (Office the Governor, 2012).

4.2.1.3 *Stakeholder Support*

Based on a literature review, public support doesn't appear to favor either agency, but stakeholders are interested in the ability to use reef resources. A public meeting was held in April 2012 to provide updates on the ability for the SONGS project North Wheeler Reef to achieve the performance standards where some stakeholders were concerned with the progress of the reef (Bro, 2012). In-depth stakeholder surveys could be employed to explore this issue further.

4.2.1.4 *Effectiveness*

Because of its authority to regulate coastal developments, the CCC is the agency most likely to require reef mitigation, as with the case of the SONGS project. However, the CDFW has extensive experience with managing habitat both in the uplands, but also in the marine environment as mandated by the Marine Life Protection Act. The CDFW also has experience with administering the state's mitigation banking program for wetlands.

4.2.1.5 *Recommendation*

It is recommended that the CDFW lead the implementation and management of the proposed reef mitigation policy due to their legislative authority and extensive experience with marine resource management. See Table 1 below for a summary of the analysis.

Table 1 – Summary of Analysis for Lead Agency

	Institutional Constraints	Regulatory Costs	Stakeholder Support	Effectiveness
Lead Agency				
California Coastal Commission				
California Department of Fish and Wildlife				

Note: Dark shading indicates higher ranking; lighter shading indicates medium/neutral ranking and no shading indicates low ranking.

4.2.2 Determine the Legislative Scope

The objective of reef mitigation is quite simple; avoid, minimize, or replace the lost function of the natural reefs by a permitted project. However, achieving this goal has proven difficult. A review of mitigation policies employed around the country demonstrates most artificial projects are focused on recreational and commercial fishing enhancement. There are currently no policies that focus specifically on impacts to natural reefs.

Most reef mitigation projects are currently developed without the benefit of a policy to guide the process as with the SONGS mitigation project. This approach provides uncertainty for both the regulatory agencies and the entity responsible for designing and constructing the proposed mitigation project.

4.2.2.1 *Institutional Constraints*

Legislation is currently in place in California which requires no-net-loss of aquatic resources, including reefs. This is a goal that is recognized both at the state level and at the federal level. Current laws; including the recently enacted Marine Life Protection Act, demonstrate the legislative will to protect California's natural resources. Therefore, there are no institutional constraints for this objective.

4.2.2.2 *Regulatory Cost*

Regulatory costs are inherently hard to predict at this point because the costs would vary depending on the specific policy developed and the nuances contained within that policy. Costs would be incurred to develop, administer, and enforce the policy. As previously mentioned, severe budget cuts in the state of California would currently limit any agency's ability to administer the program, no matter the legislative scope. Existing resources would and should be prioritized in order to move this policy development forward.

4.2.2.3 *Stakeholder Support*

Because there are several agencies that have authority over impacts to the aquatic environment, either policy goal would need to be developed with input from all stakeholders including those agencies with jurisdiction. That approach helps the other agencies to provide input and buy-in for the process, so that once the policy is implemented, it can be administered with less concern that other agencies might delay or contradict approaches to projects undertaken using this policy. This approach is consistent to the approach taken by NMFS (2010) where the CCC was a participant (Engel pers. comm., 2013).

4.2.2.4 *Effectiveness*

A single policy focused on the impacts to natural reef habitat would be more effective than modifying the scope of the existing CARP. The goal of the CARP is for the production of fish for the recreation and commercial consumption as mandated by the National Artificial Reef Plan. As stated previously, the National Artificial Reef Plan does acknowledge artificial reefs could be used for mitigation. However, the driver for reef location and design is fish production/consumption.

Consumption goals can compete with preservation goals. For example, there could be an issue with reef design standards. The current CARP allows many types of material to be used for the construction of artificial reefs as the goal is only to draw in fish. Design standards for artificial reefs for the purposes of mitigation need to be much more rigorous in order to provide more assurances that the mitigation project would create compensatory habitat. While the CARP could be modified to accommodate the requirements of mitigation, it inherently complicates the permit process by trying to accommodate two competing goals; production/consumption versus preservation/enhancement.

Recent studies of catch data suggests that marine protected areas provide an overall benefit to fisheries adjacent protected boundaries by increasing fish numbers and size when compared to fishing grounds without nearby marine protected areas (Vandeperre et. al., 2011).

4.2.2.5 *Recommendation*

The benefit creating a new policy when compared to the expansion of the existing CARP is that the policy would have a single goal of establishing a process to develop artificial reef habitat for the purpose of replacing lost habitat. As previously mentioned, the CARP has an existing goal of enhancing recreational and commercial fisheries. This goal may conflict with the goals of mitigation because the artificial reefs designed and constructed under the CARP are geared towards creating a consumptive use, where artificial reefs constructed for mitigation should be preserved with fishing and recreation discouraged to allow the ecosystem to develop and maintain. See Table 2 below for a summary of the analysis.

Table 2 – Summary of Analysis for Legislative Scope

	Institutional Constraints	Regulatory Costs	Stakeholder Support	Effectiveness
Regulatory Cost				
Modify Existing Policy				
New Policy				

Note: Dark shading indicates higher ranking; lighter shading indicates medium/neutral ranking and no shading indicates low ranking.

4.2.3 *Determine the Geographic Scope of the Policy*

Determining the geographic scope of the policy will constrain its application. Options include: 1) a focus solely on the Southern California Bight (SBC), 2) a statewide policy that is developed with special considerations based off of lead agency defined regions, or 3) a statewide policy that does not consider regions.

4.2.3.1 *Institutional Constraints*

All three policies could be implemented with little institutional constraints. Administrative boundaries are already defined by the CCC and CDFW. Both agencies also have jurisdiction within all state waters, so both the CCC and the CDFW could implement the policy at all three levels.

4.2.3.2 *Regulatory Cost*

A statewide approach is expected to provide a coordinated effort within the agency implementing the policy. Essentially no matter where the reef impact occurs, the regional office would have the same policy framework to begin from. This approach would avoid the need to "reinvent the wheel" each time mitigation is proposed for project impacts.

4.2.3.3 *Stakeholder Support*

It is expected that stakeholders would favor a statewide approach in order to reduce the uncertainties among regions in how impacts to and mitigation for impacts to natural rocky reef habitat are addressed.

All three approaches are expected to have similar effects for stakeholders as all unavoidable impacts must be mitigated. A statewide policy would provide a more equitable administration of the policy; in particular the assessment of compensatory mitigation. A statewide policy framework with or without regional considerations would provide more certainty to the agencies and the permittee that mitigation required for impacts to reef would be applied equally no matter the location in California waters. If the policy were to only focus on one particular region, there would be less certainty if the same type and quantity of mitigation would be required for similar type and quantity of impacts.

4.2.3.4 *Effectiveness*

Impacts to natural rocky reef habitat are a concern all along the California coast (NMFS 2013a). More information is known about the rocky reef habitat in the Southern California Bight, but all natural reef habitat is considered a high value resource, therefore a statewide policy that considers unique regional feature would be the most effective in pursing the goal of providing offsetting impacts for impacts to natural reef habitat. A statewide approach would also provide a coordinated effort for developing mitigation projects (NMFS 2011).

4.2.3.5 *Recommendation*

Based on the above information, it is recommended that the policy be implemented statewide with a regional approach. This would ensure reef mitigation is implemented consistently across the state and project proponents (permittee) would have a reasonable expectation of the mitigation requirements no matter where their projects may impacts and also accommodate ecological nuances of various regions, such as the SCB. See Table 3 below for a summary of the analysis.

Table 3 – Summary of Analysis for Geographic Scope

	Institutional Constraints	Regulatory Costs	Stakeholder Support	Effectiveness
Geographic Scope				
SBC				
State-wide, Broken out into Regions				
State-wide				

Note: Dark shading indicates higher ranking; lighter shading indicates medium/neutral ranking and no shading indicates low ranking.

4.2.4 Approach for Compensatory Mitigation

4.2.4.1 *Institutional Constraints*

While mitigation banking and In-lieu fee programs are allowed at the federal level, they are limited at the state level. California's mitigation banking program is limited to wetlands and conservation banking. California also does not currently manage an in-lieu fee program. New legislation would have to be enacted for either of these programs to be a viable mitigation option at the state the level. In addition, third-party programs like mitigation banks or in-lieu fee programs are operated by private parties that sell credits. In order for a reef mitigation bank or in-lieu program to be developed, it would have to get permission by the CSLC to operate on public lands (the sea floor). This could pose a conflict with the Public Trust Doctrine which allows limited use of public lands for profit; mainly oil and gas exploration.

4.2.4.2 *Regulatory Cost*

California has the agency infrastructure in place to regulate mitigation banks, even if their scope is narrowed to wetlands. It is not expected that be a tremendous undertaking to expand the program to cover other habitat types. The regulatory cost to manage individual mitigation sites is much more than managing fewer, but larger sites (Neal, 1999). Therefore it would likely be more efficient from an agency perspective to use mitigation banking or an in-lieu fee program than it would to rely on a traditional permittee responsible mitigation program. However, any increase in agency scope to manage a mitigation program would likely impose a strain on existing resources (Engel, pers. comm., 2013).

4.2.4.3 *Stakeholder Support*

Permittee support is generally favorable towards a third-party form of mitigation such as mitigation banking or in-lieu fee. The regulatory process for developing a site is much more streamlined, reducing the effort by the permittee to receive approval for their compensatory mitigation. This is approach is also appealing because there is less risk for the permittee since they are only responsible for buy the credits. The third-party is responsible for the mitigation performance and long-term management. A third-party program could also allow for a free-market approach to mitigation whereby private developers could develop a bank and sell the credits (CDFW, 2013b and Neal, 1999).

Other user groups such a fisherman or SCUBA divers may not be as favorable towards mitigation banks or in-lieu fee programs if the service areas are too large. A concept in wetland mitigation is the issue of redistribution of resources. This concept implies mitigation occurs somewhere else away from the impacted resource, provided more benefit to users in the new location (BenDor et. al., 2008). If several smaller rocky reefs are impacted and the mitigation occurs at one large bank; over time, the location of some reef habitat will be redistributed to one (or more) concentrated locations. This could benefit user groups near the mitigation bank or in-lieu fee sites, but potentially harm the user groups near the original natural reefs that were impacted.

Regulators have identified fish harvest at the SONG's site as a potential concern, impacting the productivity of the reef. The reef currently does not have any restrictions in place at the site for fishing or recreational use. No formal studies have been conducted to determine the true level of impact at the Wheeler North Reef (Engel pers. comm., 2013).

One reason for the concern regarding fishing pressure is more and new marine protected areas are being developed under the Marine Life Protection Act (MLPA). Studies of global marine protected area in temperate zones have demonstrated that marine protected areas do provide a positive benefit by increasing the biomass (Lester et. al., 2009). Other studies has have shown that marine protected areas also provide a boost to fish populations and fish size outside of the protected boundaries (Vendeperre et. at., 2011). Harvest restrictions placed at mitigation sites could further restrict consumption opportunities at rocky reef locations, but the mitigation sites themselves could increase the productivity of commercial and recreational fisheries in nearby areas open to consumption.

In order for mitigation programs to be successful; a balance, would need to be struck among stakeholders when determining the service area and consumption restrictions placed at the site. Stakeholder in-put could be gathered during the public involvement process that is required when establishing a mitigation bank or in-lieu program (USACE 2008a).

4.2.4.4 *Effectiveness*

A mitigation bank is the most effective at mitigating impacts and is the best approach and the one preferred by the USACE for mitigating wetlands degradation. The ecosystem receives the most benefit because the mitigation bank is established ahead of the impacts. In-lies fee programs would also be effective at mitigating impacts as they operate in a similar way to mitigation banks, but they are constructed later in time, typically after the ecosystem has already been impacted. A permittee-responsible mitigation site may have a higher risk of failure until more is learned about the development of artificial reefs as mitigation. The artificial reef may not be sized or function as anticipated for a permittee-responsible site.

4.2.4.5 *Recommendation*

All three types of mitigation could be implemented and may need to be implemented depending upon the availability of mitigation bank or in-lieu fee programs. Therefore a sequencing approach should be used, similar to the approached recommended by the USACE in the Final Rule (USACE 2008a). Mitigation banking should be preferred due to the certainty that mitigation "credits" are already available and because of the efficiencies gained by the permittee and the regulators to implement this approach. The benefit of having fully functioning mitigation prior to the impacts outweighs the issue mitigation banks pose with their proximity to the impacts.

In-lieu fee should be used second if a mitigation bank is not available. An in-lieu fee program offers similar benefits as a mitigation bank, but the projects are typically constructed after the impacts have occurred, therefore there is some loss of habitat function between the time the impact occurred and the time the mitigation is in place.

If neither mitigation banks nor in-lieu programs are available, then permittee responsible mitigation should be used. This approach offers more risk for failure and financial implications for the permittee if the mitigation site fails to meet the performance standards.

See Table 4 below for a summary of the analysis.

Table 4 – Summary of Compensatory Mitigation Analysis

	Institutional Constraints	Regulatory Costs	Stakeholder Support	Effectiveness
Compensatory Mitigation				
Mitigation Bank				
In-Lieu Fee				
Permittee Responsible				

Note: Dark shading indicates higher ranking; lighter shading indicates medium/neutral ranking and no shading indicates low ranking.

4.3 Objectives and Criteria for Reef Site Selection and Design

Once the policy framework has been developed, there are several elements that should be considered in constructing a formal policy. The policy needs to provide information to allow more certainty between both the regulatory agencies and the permittee. Key elements include site selection, design, performance criteria and monitoring. As demonstrated with the two case studies described further in Appendix 1, there are many techniques for evaluating potential sites. However, site selection should be broken out into two distinct categories; physical and biological.

Physical site selection involves the process of excluding sites due to physical constraints. For example, locations within an active navigations channel should be avoided because navigation channels are routinely dredged to maintain proper depths and a reef could pose a navigational hazard. An artificial reef should also be placed in areas to avoid conflicts with other human uses such as commercial fishing or in proximity to sewage outfalls, which can create poor water quality and affect the success of the reef.

Substrate bottom contours are also a key physical feature that should be considered. An artificial reef should not be placed on existing rocky habitat. This would create additional impacts to rocky habitat with limited improvement. However, investigations should be conducted to determine tidal currents to ensure that the potential for scour and siltation of the artificial reef would be minimal (Reed et al 2006 and Barber et al 2009).

Biological considerations for site selection described further in the case studies (Appendix 1) should consider two key criteria in order to improve the chance of a successful reef mitigation project. The first is to define the objective of the mitigation. Is the reef intended to simply create new rocky reef structure or is the artificial reef intended to create new structure, but also mimic the habitat of the natural reef that is being impacted? Or is the objective of mitigation to replace the entire function of the habitat that is lost?

With the assumption that the mitigation should replace the loss of habitat function, then an artificial reef should be placed as close to the impacted natural reef as possible, unless the impacted area continue to degrade, risking the success of the mitigation site. As demonstrated by the Wheeler North Reef project, while the reef mimicked to a certain extent the reference reefs nearby, it did not mimic the habitat function it was intended to replace; specifically fish production. An artificial reef placed near the impacted reef would be assumed to provide similar habitat function of the natural reef due to proximity to similar conditions such as ocean currents, nutrients and depth.

Proximity to natural reef is also a consideration when siting an artificial reef due to the need to initially recruit species. As with the Pendleton Artificial Reef, it was assumed that it would be more productive to place a reef in a barren area away from other natural reefs. What was discovered, however, was that sessile benthic invertebrates could not travel large distances over less desirable mud/sand habitat to colonize a new reef (Wilson et al. 1990). By locating an artificial reef near a natural reef, it provides a higher probability for invertebrates to colonize the reef. The invertebrates would then provide food to retain other species such as fish.

An integral part of the site selection would also include public involvement. Public involvement would typically occur as part of the permit process for a project that may impact reef habitat. As part of the permit process, the permittee would identify the proposed mitigation. Once the permit application is available for public comment, stakeholders and the public could provide feedback on the proposed location of the mitigation.

4.4 Analysis of Objectives and Criteria for Reef Site Monitoring

Monitoring of a mitigation site is an integral component to determine if the mitigation project has been successful in providing the desired habitat function to offset the impacts from a project. The USACE requires a minimum of 5 years for monitoring of a mitigation site (USACE 2008b). However, Barber et al., (2012b) pointed out that it could take up to 20 years for a reef in Boston Harbor to provide full function and Reed et al., (2012) mentions that certain performance criteria at the Wheeler North Reef may never be met. A monitoring period of five years appears to be too short based on the findings of the case studies discussed in Appendix 1.

In order to ensure the success of a reef mitigation project, a monitoring period of longer than 5 years should be established or until the reef reaches its performance criteria. The party responsible for the mitigation should also provide adequate funding to assure that long-term monitoring will take place. A mitigation plan also needs monitoring in case adaptive management strategies need to be employed to ensure that a mitigation reef fulfills its design objectives. For example, in the case of Wheeler Reef North, additional rock may be needed in order to recruit more algal and benthic invertebrates.

Once a project that will impact rocky reef habitat has been approved, an assessment of its habitat function should be conducted to understand what is going to be affected by the project and what the goals for mitigation should be. This baseline assessment will provide key information to establish the monitoring criteria by professional marine biologists.

Upon selection of a site to place the mitigation reef as previously discussed in Section 4.3, nearby natural rocky reef habitat should be surveyed to determine a habitat reference for the mitigation reef (MDMF 2008). When the impacts to the natural reef and baseline data gathered from the reference reef have been determined, monitoring criteria should be developed and construction of the reef can begin. Reefs have a tendency to vary in species composition and densities depending upon the season (Barber et al 2009). Spring through fall is the typical "growing season" for reefs and is when monitoring would be most appropriate. Monitoring should be conducted annually during summer periods until the performance criteria are met. As mentioned previously mentioned rocky reefs are integral for kelp forest recruitment. Summertime measurements of kelp frond densities are an important measure of kelp forest complexity and the kelps ability to support other species (Reed et al 2010). If performance criteria are not met or the reef habitat begins to trend downward as with the case of the Wheeler North Reef, then adaptive management strategies should be employed. Adaptive management strategies are part of the USEPA and USACE final mitigation rule and are meant to improve mitigation performance (USACE 2008a). Having these strategies are important, especially since reef mitigation it relatively new and there are many unforeseen factors that could change future mitigation performance, such as water quality, fishing practices, or future development.

4.5 Recommendations for Reef Mitigation Policy in Southern California

The permitting process for projects with the potential to impact natural reef habitat is overseen by several state and federal authorities. Each regulatory agency has its own specific mandates and policies regarding mitigation. For example, the 2008 Final Rule by the USACE and USEPA determined that mitigation banking and in-lieu fee programs are more preferred than individual mitigation sites. The reason for this is that traditionally individual wetland mitigation sites were small and segmented. While the mitigation generally met the requirements of offsetting impacts, there was not a great ecological benefit to the watershed. By creating a large singular wetland mitigation bank; there is greater benefit to the watershed than several small sites scattered throughout. However, this approach of greater ecological benefit does not necessarily apply to the marine environment.

Compensatory mitigation should be considered carefully. Site selection should include exclusion mapping to locate a mitigation site where it would have the best chance of success. The mitigation site should also be located near natural reefs to promote colonization of the artificial reef by local organisms.

Compensatory mitigation also needs to include provisions for monitoring to ensure the reef site meets its objective to compensate for impacts. Monitoring criteria should be established based on reef surveys prior to the impacts. Monitoring durations should be considered carefully. Artificial reefs tend to take a longer progression to fully develop. (Sources) Current standards for wetland mitigation sites are five years, but 10 or more should be considered.

The marine environment is not defined by watersheds. It is defined by unique ecological function, such as the SBC, or it may only be defined by regional areas (USACE 2008). As demonstrated by the monitoring of the SONGS project, placement of a reef outside of the immediate area of impact may result in variations of the types of organisms found. While the artificial reef retained a similar volume of fish relative to the reference reefs nearby, the diversity was much less than that of the original impact site. Therefore it would be difficult to define a service area. The service area may be limited for a reef mitigation bank or in-lieu fee program. The service area is the maximum distance from a project impact that a mitigation bank can reasonably be assumed to offset the impacts. The limits would likely be constricted because it would be difficult to expect a reef mitigation bank to provide similar habitat functions.

A statewide policy needs to be developed that takes a holistic approach and incorporates the regulatory requirements of each agency. As discussed above, the CDFW is the agency most likely to effectively implement the policy. Each agency has their own set of triggers under current legislation to require compensatory mitigation for impacts to natural reefs. In certain cases one agency's trigger may be met, while another is not. For example, the SONGS project did not directly trigger a USACE permit because it did not place fill in Waters of the U.S. However, the cooling water effluent did impact kelp forest and therefore triggered a CCA permit. Yet, the mitigation required by the CCA permit (the SONGS artificial reef) required a USACE permit because of the material placed in the water to create a reef. Therefore a reef mitigation policy needs to be developed with the guidance and input of all regulatory agencies that are likely to issues permits or approvals for such projects. The NMFS took the approach of engaging other regulators as they drafted their draft eelgrass mitigation policy, which resulted in buy-in and approval from other agencies such as the CCC (Engel pers. comm. 2013).

The mitigation policy should also be developed with input from other stakeholders as well. Stakeholders could include potential permittees, businesses and industries involved with water-dependent development as well as the public who may be interested in using the reef for commercial or recreational fishing or other recreational purposes. Involving the stakeholders could help to guide the formal fleshing out of the policy once the framework is in place. This approach would help to identify concerns from stakeholders before the policy is implemented.

The reef mitigation policy should also incorporate generally accepted methods for defining site selection and monitoring as described in Section 4.3 and 4.4. In addition, the policy should include provisions for adaptive management. Adaptive management is a requirement of the USACE and USEPA Final Rule, yet it hasn't been included as a component of any of the reef mitigation policies previously discussed in this capstone project. The value of adaptive management has become especially apparent for the SONGS project because some performance criteria are not being met and may never be met with the current reef design. The CCC has discretion and could compel Southern California Edison to modify the reef in order to try to bring the reef into compliance with the monitoring criteria.

A second issue is that the SONGS artificial reef was placed with an expectation to offset impacts for at least 30 years (from prior operation of the nuclear plant), plus any future operations. Since the artificial reef has yet to meet all of its performance criteria, the SCE is not getting credit for the first three years of operation of the reef. The clock won't start until all performance criteria are met and then the reef must continue to perform for 30 years (Engel pers. comm. 2013).

If an adaptive management strategy had been required as part of the reef mitigation policy for the SONGS project, there could have been a process in place to address this issue. For example, an adaptive management strategy could identify the steps that need to take place, such as identification of the issue (not meeting performance standards), who needs to be contacted and when, and potential actions to remedy the situation. The reef mitigation policy would not need to describe the potential specific actions that would be required, but it would establish process and expectations upfront, so when issues arise, they can be effectively managed.

A comprehensive reef mitigation policy developed with input from regulators and stakeholders would provide a framework for future artificial reef mitigation projects in the state of California and help establish more certainty that those projects will function properly and achieve their goal of no net loss to aquatic resources.

5. CONCLUSIONS

The concept of using artificial reefs for the purpose of replacing the loss of habitat function due to permitted impacts is relatively new. The need and application of reef mitigation varies greatly from state to state. The state of California is currently analyzing the effectiveness of artificial reefs as mitigation, but does not have a policy framework in place to formally guide the process. A need for a mitigation policy has been identified due to anticipated future coastal development projects that will likely impact natural rocky reefs.

Based on review of reef mitigation policies and frameworks from other states and analysis of policy framework objectives; I conclude a statewide policy focusing on reef mitigation development would provide regulators with a useful tool. A policy will coordinate the development of mitigation projects as well as identify the critical design, siting, construction, monitoring and management parameters to ensure the most effective approach for reef mitigation.

The future for implementing such a policy remains unclear. There is legislative support to implement policies that reduce environmental degradation. However, agency funding remains a limiting factor in the development and implementation of new policies. If resources are secured and the process moves forward, this capstone could be used by the resource agencies to begin formal policy development.

A formal reef impact policy will need to include plenty of stakeholder involvement. There are many user groups of natural rocky reefs. Impacts to the reefs limit the remaining available areas available to user groups; especially to consumer groups like fishermen. If mitigation banking is implemented, then location and availability of some reef locations may shift as well.

Additional research is needed to better inform the policy development process. The concept of artificial reefs attracting, versus producing more fish should be studied carefully to ensure the reefs can meet their mitigation objectives without reducing the population of fish at other natural reefs. Restricting consumption of fish at mitigation sites also needs further study to determine the direct and indirect effects this action may have.

If these issues can be addressed; implementing a policy to address impacts to natural rocky reefs will provide both the agencies and permittees with more certainty and consistency with the permit process.

6. REFERENCES

Anchor QEA, 2012. Port of Los Angeles Umbrella Mitigation Banking Agreement Prospectus. Prepared for the Port of Los Angeles by Anchor QEA. May 2012.

Barber, J.S., D.M. Chosid, R.P. Glenn, and K.A. Whitmore. 2009a. A systematic model for artificial reef site selection. New Zealand Journal of Marine and Freshwater Research, 2009, Vol. 43: 283-297.

Barber J.S., Whitmore, K.A., Rousseau, M., Chosid, D.M., Glenn, R. P., 2009b. Boston Harbor Artificial Reef Site Selection and Monitoring Program. Massachusetts Division of Marine Fisheries. Technical Report TR-35.

Bartone, S.A., 2006. A Perspective of Artificial Reef Research: The Past, Present, and Future. Bulletin of Marine Science, 78(1): 1-8, 2006.

BenDor, T., Brozovic, N., Pallathucheril, V.G., 2008. The Social Impacts of Wetland Mitigation Policies in the United States. Journal of Planning Literature 2008 22:341. Available from http://jpl.sagepub.com/content/22/4/341.

Bedford, D.W., 1992. Proposal for Improving Fishing Opportunities off Pt. Loma by Construction of an Artificial Reef. Prepared for the California Coastal Commission.

Bentivolgio, A., 2003. Compensatory Mitigation for Coral Reef Impacts in the Pacific Islands. Final Report. United States Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office.

Bro, D., 2012, April 10. San Onofre artificial reef not meeting state standards. *Orange County Register*. Available from: http://www.ocregister.com/articles/reef-348671-kelp-fish.html.

Burger, Nicholas, Liisa Ecola, Thomas Light and Michael Toman. Evaluating Options for U.S. Greenhouse-Gas Mitigation Using Multiple Criteria. Santa Monica, CA: RAND Corporation, 2009. http://www.rand.org/pubs/occasional_papers/OP252.

CCC (California Coastal Commission), 2013. Website, Accessed: June 2, 2013. Available from: http://www.coastal.ca.gov/whoweare.html.

CCKA (California Coastkeeper Alliance), 2008. Southern California Giant Kelp Restoration Project.

CDFG (California Department of Fish and Game), 2001. A guide to the Artificial Reefs of Southern California. Available from: http://www.dfg.ca.gov/marine/artificialreefs/index.asp

CDFW (California Department of Fish and Wildlife), 2012. Report to the Legislature; California Wetlands Mitigation Banking. January 2012.

CDFW, 2013. Marine Life Protection Act. Accessed March 17, 2013. Available from: http://www.dfg.ca.gov/mlpa/

CFGC (California Fish and Game Comission), 2013. Website Accessed June 2, 2013. Available at: http://www.fgc.ca.gov/public/information/.

CDFW, 2013b. Conservation and Mitigation Banking. Accessed: May 17, 2013. Available at: http://www.dfg.ca.gov/habcon/conplan/mitbank/.

California Marine Life Protection Act (As Amended). Fish and Game Code Sections 2850-2863. July 2004.

CNRA (California Natural Resources Agency), 2013. CEQA: The California Environmental Quality Act. Accessed May 17, 2013.Available at: http://ceres.ca.gov/ceqa/.

CSLC (California State Lands Commission), 2001. Public Trust Policy.

CSLC, 2007. Public Trust Doctrine.

CSLC, 2013. California State Lands Commission Website. Accessed May 16, 2013. Available from: http://www.slc.ca.gov/.

DMF (Massachusetts Department of Fish and Game, Division of Marine Fisheries. Accessed March 20, 2013. Available from: http://www.mass.gov/dfwele/dmf/programsandprojects/artificia.htm

Elwany, M. Hany S., Eaker, C., Grove, R. S., Peeler, J., 2011. Construction of Wheeler North Reef at San Clemente, California. Journal of Coastal Research. S1, 59, 266-272, West Palm Beach, Florida.

Engel, J., 2013. Personal Communication. March 27, 2013.

Figley, B., 2005. Artificial Reef Management Plan for New Jersey.

FFWC (Florida Fish and Wildlife Commission; Division of Marine Fisheries), 2003. State of Florida Artificial Reef Strategic Plan. November 23, 2003.

GCMP (Guam Coastal Management Program), 2009. Guam Compensatory Mitigation Policy. May 2009.

Hueckel, G. J., R. M. Buckley, and B. L. Benson, 1989. Mitigating rocky habitat loss using artificial reefs. Bull. of Mar. Sci. 44: 913-922.

Jesse, W.N., A.L. Carpenter, and J.W. Carter. 1985. Distribution Patterns and Density Estimates of Fishes on a southern California Artificial Reef with Comparisons to Natural Kelp-Reef Habitats. Bulletin of Marine Science, 37(1): 214-226, 1985.

Krutzikowsky, G., 2013. Personal Communication. March 21, 2013.

Lewis. R.D., McKee, K., K., 1989. A Guide to the Artificial Reefs of Southern California. Accessed May 14, 2013. Available at: http://www.dfg.ca.gov/marine/artificialreefs/.

Loftus, J. A., Stone, R.B., 2007. Artificial Reef Management Plan for Maryland. Maryland Environmental Service Contract 06-07-58.

Miller, M. W., 2002. Short Communication: Using ecological processes to advance artificial reef goals. ICES Journal of Marine Sciences, 59: S27-S32. 2002

NCDNR&CD (North Carolina Department of Natural Resources and Community Development; Division of Marine Affairs), 1998. North Carolina Artificial Reef Master Plan. October 1998.

NMFS (National Marine Fisheries Service). 1991. Habitat Protection Policy. Revised October 25, 1991. Accessed, February 4, 2013. Available at: http://swr.nmfs.noaa.gov/hdc/protpol.htm.

NMFS (National Marine Fisheries Service). 2011. Drat California Eelgrass Mitigation Policy. Southwest Region. December 7, 2011.

NMFS, 2013a. Southwest Region Office; Habitat Conservation Division. Accessed, February 4, 2013. Available at: http://swr.nmfs.noaa.gov/hcd/HCD_webContent/socal/hcdsocal.htm.

NMFS, 2013b. Summary of the Magnusson-Stevens Act. Accessed: June 2, 2013. Available at: http://www.nmfs.noaa.gov/sfa/magact/.

NOAA (National Oceanic and Atmospheric Administration), 2007. National Artificial Reef Plan (as Amended): Guidelines for Siting, Construction, Development, and Assessment of Artificial Reefs. February 2007.

NOAA, 2012. State Coastal Zone Boundaries. February 9, 2012.

NOAA, 2013a. Olympic Coast National Marine Sanctuary. Accessed, February 4, 2013. Available at: http://olympiccoast.noaa.gov/living/habitats/rockyreef/rockyreef.html.

NOAA, 2013b. Coastal Zone Management website. Accessed on June 2, 2013.

Available at: http://coastalmanagement.noaa.gov/czm/czm_act.html. Neal, J., 1999. *Paving the Road to Wetlands Mitigation Banking*, 27 B.C. Envtl. Aff. L. Rev. 161 (1999), http://lawdigitalcommons.bc.edu/ealr/vol27/iss1/6.

Office of the Governor, 2012. Governor Jerry Brown Signs the 2012-2013 Budget. June 27, 2012. Accessed on June 2, 2013. Available at: http://gov.ca.gov/news.php?id=17607.

Oregon Territorial Sea Plan. 1994. Available at: http://www.oregon.gov/LCD/OCMP/Pages/Ocean_TSP.aspx Accessed, March 17, 2013.

Palsson, W.A., Northup, T.J., Barker, M.W., 1998. Puget Sound Ground Fish Management Plan (Revised). December 1998.

Pondella, D., J. Williams, J. Claisse, R. Schaffner, K. Ritter and K. Schiff. 2011. Southern California Bight 2008 Regional Monitoring Program: Volume V. Rocky Reefs. Southern California Coastal Water Research Project, Costa Mesa, CA.

POLB (Port of Long Beach), 2006. Strategic Plan 2006-2016. Accessed June 2, 2013. Available at: http://www.polb.com/about/plan.asp.

POLA (Port of Los Angeles), 2012. Strategic Plan 2012-2017. Accessed June 2, 2013. Available at: http://www.portoflosangeles.org/pdf/strategic_plan_2012_lowres.pdf

Reed, C. D., S. C. Schroeter, and D. Huang. 2005. Final Report on the Findings and Recommendations of the Experimental Phase of the SONGS Artificial Reef Mitigation

Project. Prepared for the California Coastal Commission, Marine Science Institute, University of California, Santa Barbara, 1 August 2005.

Reed, C.D., S. C. Schroeter, D. Huang, T.W. Anderson, and R.F. Ambrose. 2006. Quantitative Assessment of Different Artificial Reef Designs in Mitigating Artificial Reef Losses to Kelp Forest Fishes. Bulletin of Marine Science, 78(1): 133-150, 2006.

Reed, C. D., S. C. Schroeter, M. H. Page, and M., Steele., 2010. Monitoring Plan for the SONGS Reef Mitigation Project. Prepared for the California Coastal Commission. Updated March, 2010.

Reed, C. D., S. C. Schroeter, and M. H. Page. 2012. Annual Report of the Status of Condition C: Kelp Reef Mitigation; San Onofre Nuclear Generation Station (SONGS) Mitigation Program. Prepared for the California Coastal Commission, Marine Science Institute, University of California, Santa Barbara, June 2012.

Reynolds, B., 2007. Artificial Reefs as a Restoration Tool for Alaska's Coastal Waters. Final Report to U.S. Fish and Wildlife Service, Alaska Coastal Program. Prince William Sound Science Center. Cordova, AK. 13pp.

Rousseau, M.A., 2008. Massachusetts Marine Artificial Reef Plan. Massachusetts Division of Marine Fisheries Policy Report FP-3. June 2008.

USACE (U.S. Army Corps of Engineers), 2008a. *Compensatory Mitigation for Losses of Aquatic Resources Final Rule*. Federal Register Volume 73 Number 70. 19594-19705.

USACE, 2008b. Regulatory Guidance Letter 08-03. *Minimum Monitoring Requirements for Compensatory Mitigation Projects Involving the Creation, Restoration, and/or Enhancement of Aquatic Resources.*

USACE, 2013a. Electronic Permit Guidebook. Accessed May 16, 2013. Available at: http://www.nws.usace.army.mil/Missions/CivilWorks/Regulatory/PermitGuidebook.aspx

USACE, 2013b. Regulatoty In-Liue Fee and Bank Information Tracking System. Access May 16, 2013. Available at: https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:158:3586036599888463::NO:RP:P27_BUTTON_KEY:1.

USEPA, 2013a. Summary of the Clean Water Act; 33 U.S.C. §1251 et seq. (1972). Accessed February 25, 2013. Available at: http://www.epa.gov/regulations/laws/cwa.html.

USEPA, 2013b. Summary of Section 10 of the Rivers and Harbors Act of 1899. Accessed June 2, 2013. Available at: http://el.erdc.usace.army.mil/emrrp/emris/emrishelp5/rivers_and_harbors_acts_legal_matters.htm.

USEPA, 2013c. Sumary of the Endangered Species Act. Accessed: June 2, 2013. Available at: http://water.epa.gov/type/oceb/fact3.cfm.

USFWS (United States Fish and Wildlife Service), 2004. Investigations of Mitigation for Coral Reef Impacts in the U.S. Atlantic: South Florida and the Caribbean. Prepared by the U.S. FWS, Southeast Region.

Wilson, K.C., Lewis, R.D., Togstag, H.A., 1990. Artificial Reef Plan for Sport Fish Enhancement. Administrative Report No. 90-15. November 1990.

Vandeperre, F., Higgins, R. M., Sánchez-Meca, J., Maynou, F., Goñi, R., Martín-Sosa, P., Pérez-Ruzafa, A., Afonso, P., Bertocci, I., Crec'hriou, R., D'Anna, G., Dimech, M., Dorta, C., Esparza, O., Falcón, J. M., Forcada, A., Guala, I., Le Direach, L., Marcos, C., Ojeda-Martínez, C., Pipitone, C., Schembri, P. J., Stelzenmüller, V., Stobart, B. and Santos, R. S. (2011), Effects of no-take area size and age of marine protected areas on fisheries yields: a meta-analytical approach. Fish and Fisheries, 12: 412–426. doi: 10.1111/j.1467-2979.2010.00401.x

APPENDIX 1 – CASE STUDIES

San Onofre Nuclear Generation Station (SONGS) Mitigation Program, California

In 1982 the State constructed the Pendleton Artificial Reef (PAR) to determine if kelp communities could be established on man-made structures (Hymanson et al 1989). A secondary purpose of the reef was also to determine if artificial reefs could be used to mitigate impacts from coastal energy plants. After five years of monitoring, PAR showed signs that the reef was reaching species equilibrium and indicated it could provide habitat function similar to natural reefs (Grant et al 1982).

Following this experiment, the CCC through its reauthorization process for a coastal development permit for the SONGS project, included Condition C in its permit for the continued operation of the power generation facility. Condition C required the Southern California Edison Company to construct an artificial reef to create 150 acres of kelp forest to compensate for the loss of natural kelp forest. Condition C specified that the reef would be constructed in two phases. The first phase would be an experimental phase, testing various types of materials and designs to determine which combination of material and design would provide the most likelihood of reef success. The reef for the first phase would be monitored for five years and the results would then drive the development of the full mitigation reef.

After five years of monitoring and analysis of data, Reed et al (2005) determined that quarry rock and concrete rubble supported similar habitat communities. It was also determined that a reef design that incorporated low relief (no higher than approximately 1 meter above the seabed) and a coverage of rocky material between 42-86% would provide the best opportunity for reef success. The recommendations based on the monitoring also suggested the full reef be constructed near the existing 144-ha project site, but avoiding the northern most location due the potential of reef burial from sand inundation as well as existing hard bottom areas know to support kelp forest and commercial and recreational fishing. One final consideration is the anticipated recruitment of spiny sea fan (muricea). Based on monitoring, muricea has a reasonably high expectation of forming high densities on future reefs and could compete with kelp for space. The report recommends further studies to determine if muricea recruitment and growth can be controlled (Reed et al 2005).

The entire Wheeler North Reef was constructed in 2008. As part of permit condition C, the reef is being monitored each year for the life of the power plant, which is expected to be from 20-30 years (Elwany et al 2011). There are 14 performance standards for which the reef must meet in order to determine success. Through the first three years of monitoring, the artificial reef is meeting 9 of the 14 performance standards, suggesting the reef is not in compliance with the permit (Reed et al, 2012).

Table 5 – North Wheeler Reef Summary of Performance Criteria Achieved

Performance Criteria	2009	2010	2011
Hard Substrate	Yes	Yes	Yes
Area of Adult Giant Kelp	No	Yes	Yes
Fish Standing Stock	No	No	No
Resident Fish Density	Yes	Yes	Yes
Resident Fish Species Numbers	Yes	Yes	Yes
Fish Reproductive Rate	Yes	Yes	No
Young-of-Year Fish Density	Yes	Yes	Yes

Young-of-Year Fish Species Numbers	Yes	Yes	Yes
Fish Production	Yes	Yes	Yes
Algal and Invertebrate Percent Cover	No	No	No
Mobile Invertebrate Density	No	No	Yes
Algal and Invertebrate Species Number	No	No	No
Benthic Food Chain Support for Fish	Yes	Yes	No
Invasive and Undesirable Species	Yes	Yes	Yes
Performance Criteria Met (out of 14)	9	10	9

Source: Annual Report of the Status of Condition C: Kelp Reef Mitigation. San Onofre Nuclear Generation Station (SONGS) Mitigation Program (Reed et al 2012).

Reed et all (2012) concluded after the 2011 monitoring period that based on monitoring results conducted to date that the criteria pertaining to fish standing stock, algal and invertebrate percentage cover and algal and invertebrates species numbers are not likely to be met anytime in the near future. In addition, the remaining two criteria not met (fish production rates and benthic food chain support for fishes) regressed with respect to the first two years of monitoring.

While the Wheeler North Reef has generally shown promise, as mentioned above, certain criteria have not been met. Reed et al (2012) hypothesized as to the potential short comings of meeting the objectives. They state that the criterion for fish standing stock has only achieved approximately 50% of its goal of 28 tons of fish. The total was the estimated loss from the impacts due to the SONGS project. They speculate that a reef the size of the North Wheeler Reef (176 acres) may not be the correct size. They tested this hypothesis by taking the results of observations at both the first phase of the artificial reef, plus the results from observations at two control natural reefs and factoring them to make them commensurate with a reef the size of the North Wheeler Reef. The results were mixed. One natural reef indicated that it could achieve this goal, while the second natural reef indicated results similar to the Wheeler North Reef. In addition, the Phase 1 reef did show higher densities, but this was attributed to the experimental designs that included portions with high relief with a higher rock coverage density that may be more favorable to fish. This is consistent with the results of the Phase 1 monitoring (Reed et al 2012).

Regarding the criteria of fish production rates, Reed et al (2012) concluded that the Wheeler North Reef did not meeting this criterion because of the lower fecundity index for sheephead and to a lesser extent kelp bass, which resulted from a lower proportion of spawning individuals.

The lower percent of algal cover and invertebrates was thought to be due in part to the increased kelp canopy cover at Wheeler North Reef, which reduces the amount of light penetrating to the understory. Another contributor could be the lower percent of rock habitat, which is preferred by kelp, but provides less surface area for algae and invertebrates to develop. The North Wheeler Reef was constructed with approximately 42% rocky habitat coverage whereas the two reference reefs were 48% (Barn) and 58% (San Mateo). The low algal cover was also thought to have a direct link to the final criterion of benthic food chain support by reducing the available food and habitat preferred by prey species (Reed et al 2012).

Boston Harbor Artificial Site

In 2004 The Massachusetts Division of Marine Fisheries (MDMF) received monetary compensation funds Algonquin Gas Transmission Company to develop an artificial reef (Boston Harbor Reef) for mitigation of unavoidable impacts to natural rocky reef habitat from the construction of an underwater natural gas pipeline. This mitigation project was constructed prior to the implementation of the Massachusetts Marine Artificial Reef Plan. MDMF established lobster production as the main goal of the artificial reef due to the commercial fishery in the area. The reef was constructed as series of reefs in the spring of 2006 (Barber et al 2009b).

The Boston Harbor Reef was developed using a rigorous site selection process that MDMF developed with the intent to be applied to future reef site selection processes. The seven step site selection process employed exclusion mapping to identify likely sites for reef placement. The term exclusion mapping is used to describe a method preferred by scientist where cartographic information is used to exclude undesirable areas for placing artificial reefs (Barber et al 2009).

The exclusion mapping for the Boston Harbor Reef used several criteria within three general physical parameters; substrate composition, bathymetry, and proximity to the impacts caused by the pipeline. An intensive investigation was conducted to gather baseline information on the above criteria to verify and improve the initial mapping model. The model exercises resulted in 24 potential sites (Barber et al 2009b).

The first five steps of the site selection process involved additional data collection related to the physical parameters. A weighting and ranking analysis was applied to the remaining 24 sites. The ranking system incorporated multiple aspects of the site selection criteria used in the exclusion mapping. In addition to the ranking parameters, MVMF also used a principal component analysis (PCA) to examine how particular variables affected the sites' overall score. The PAC demonstrated how high and low-ranking sites grouped in comparison to each other (Barber et al 2009b).

Based on the results of the first five steps; the sites were screened down to three. The final two steps involved assessing biological baseline conditions with a focus towards lobster larva populations at each site. Sites with less larva were ranked higher with the assumption that the proposed reef would provide a greater lift in areas were populations are lower. A final site was selected and constructed in the spring of 2006. After construction, MDMF then employed a rigorous monitoring regime (Barber et al 2009b).

The primary goal of the monitoring was to establish a timeframe for reef succession, but the monitoring program was also intended to review the potential for the artificial reef to recruit certain species such as benthic invertebrates and fish. The program used three sampling methods; permanent transects, benthic air-lift sampling and fish tagging. The monitoring occurred at the locations; the reef site, a nearby natural reef site and at locations along the rocky habitat near pipeline itself. The results of the monitoring were compared to the species populations found at the nearby natural rocky reef and rocky habitat near the pipeline project to understand if the artificial reef can mimic the natural reef habitat (Barber et al 2009b).

Monitoring only occurred during 2006 and 2007. Results of the monitoring were similar compared to other reef monitoring efforts; communities of organisms began to settle, soon after reef construction. However, Barber et al. (2009b) concluded that after two years, the communities had not attained the habitat function of the nearby natural reefs. They pose the following question regarding the definition of mitigation. If mitigation were defined as providing habitat for organisms to establish, then the reef was a success, however if mitigation is defined as providing habitat for organisms, such that the community resembles nearby natural reef communities, then the project did not reach those goals. Barber et al (2009b) could only speculate as to the timeline for when an artificial reef may reach the goal of providing a fully functioning community, but did emphasize the need for a rigorous site selection process and long-term monitoring to create a framework for successful reef development.