Appendix A1

Construct Artificial Reefs and Fishing Access Improvements

A1.1 GOALS AND NEXUS TO INJURY

As a result of the historical releases of DDTs and PCBs by the Montrose defendants, several species of fish, particularly those associated with soft sediments, in certain coastal areas continue to accumulate levels of contamination that make it advisable for people to avoid or limit their consumption. The goal of constructing artificial reefs and fishing access improvements is to restore lost fishing services by changing the species composition of fish in selected fishing areas. In this appendix, we categorize fish species based on the habitats with which they are most commonly associated. The term "bottom" is commonly used to describe the substratum. Thus, soft-bottom fishes are those that are commonly associated with sand or mud substrata, and hard-bottom fishes are those that are commonly associated with reef or rocky substrata. An additional category of fish, water-column-feeding fish, refers to pelagic fishes that feed on prey that is suspended in the water column (e.g., pelagic zooplankton).

The premise of this restoration action is that fish, particularly white croaker, that are associated with soft-bottom habitats feed on benthic organisms from the contaminated sediments and are consequently the most highly contaminated species. In contrast, fish associated with hard-bottom or pelagic habitats feed on organisms that are either living in the water column or attached to hard substrate and are consequently less contaminated. This premise is supported both by (1) data collected by the Los Angeles County Sanitation Districts, which demonstrate a repeated pattern of lower contamination levels in kelp bass and black surfperch relative to white croaker, and (2) the current fish consumption advisories, which are broader and more restrictive for white croaker than for hard-bottom species.

The construction of a reef is likely to change the types of fish in an area because soft-bottom species do not typically inhabit reef habitats (Allen 1999). The primary benefit of these projects will be to displace these highly contaminated, soft-bottom fishes with water-column-feeding and hard-bottom species, which tend to be lower in contamination. Building reefs will also provide ecosystem benefits by increasing the production of fish whose tissues contain lower concentrations of contaminants (Dixon and Schroeter 1998). Reef construction may be complemented at some sites by improvements to fishing access (e.g., piers or other amenities) to promote the use of the enhanced fishing sites, to heighten awareness of how habitat affects the concentration of contaminants in different species of fish, and to provide compensatory restoration for past losses in fishing opportunities due to limitations imposed by fish consumption advisories.

Both elements of this restoration action (using artificial reefs to replace contaminated soft-bottom fishes with hard-bottom species and constructing improved public access to such sites) have a strong relationship to the lost fishing services of the Montrose case and act as both primary and compensatory restoration of lost fishing opportunities. The reef element also addresses the objective of restoring fish and the habitats on which they depend.

A1.2 BACKGROUND

Artificial reefs have been employed extensively throughout the world, including California coastal waters, as a means to improve fishing, diversify fish communities, and increase productivity. Artificial reefs may be broadly classified according to their fundamental purposes:

fishing reefs and fish production reefs. A fishing reef (sometimes referred to as a Fish Aggregation Device [FAD]) typically provides little or no fish production value itself, functioning instead to aggregate certain species for the purpose of recreational or commercial catch. A production reef is constructed to promote settlement, growth, and survival of resident reef species over a long time frame for the purpose of increasing fish production. It is also possible to design projects that incorporate both elements, for instance by placing fishing reefs in proximity to production reefs or by restricting fishing to a limited portion of a reef that is sufficiently large to allow the remaining areas to function undisturbed as production sites and to sustain the fishing portion. Natural reef habitats act both to aggregate and to produce fish.

The California Department of Fish and Game (CDFG) administers the California Artificial Reef Program (California Fish and Game Code Sections 6420–6425), which has a long history of designing and constructing artificial reefs for purposes of increasing local production and abundance of fishes that are targeted by recreational anglers. To date, approximately 30 artificial reefs have been constructed involving over 100 modules and a broad range of designs and goals (Figure A1-1). Although some reefs in California have been called “fishing or fishing opportunity reefs,” the California definition of artificial reef requires that fishing reefs be designed and constructed to function as habitat that supports a productive and sustainable marine community typical of natural reef habitats rather than simply functioning as a FAD. This approach has generated a large amount of information regarding species composition, community succession, and productivity for artificial reefs (Ambrose 2000, Dixon and Schroeter 1998).

The CDFG program has developed a specific definition of artificial reefs that includes the contingency that they simulate natural reef habitats:

> “Artificial reef” means manmade or natural objects intentionally placed in selected areas of the marine environment to duplicate those conditions that induce production of fish and invertebrates on natural reefs and rough bottoms, and that stimulate the growth of kelp or other mid-water plant life which creates natural habitat for those species. (California Fish and Game Code Section 6421a)

Additional information on reef productivity and community structure has been generated in the past two decades by construction of a series of “developmental” reefs specifically designed to evaluate and compare how various design elements affect biological productivity and community structure. Developmental reefs have been built at Pendleton, Pitas Point, Santa Monica Bay, Marina Del Rey #2, Oceanside #2, Pacific Beach, Carlsbad, and Topanga. These developmental reefs generally consist of a series of rock modules with different rock sizes, relief profiles, and depths in paired replicates. The California Fish and Game Code states that “production” reefs would ultimately be built based on the information gained from the study of these “developmental” reefs (California Fish and Game Code Section 6420). However, due to cuts in funding for the CDFG artificial reef program, the intended studies of the existing developmental reef sites have not occurred (Parker, pers. comm., 2004).

A1.2.1 Relevant Models for Reefs That Would Meet MSRP Restoration Objectives

Increasingly, artificial reefs have been constructed to replace or mitigate for aquatic resources impacted by human activities (Ambrose 1994). Mitigation reefs have been constructed in recent years at several sites within the Southern California Bight, including Bolsa Chica, Long Beach Harbor, near the Angels Gate entrance to Los Angeles Harbor, in San Diego Bay, and offshore of Camp Pendleton. To mitigate for impacts to a kelp forest caused by releases of warm water by the San Onofre Nuclear Generating Station (SONGS), the utilities that operate SONGS are currently developing near San Clemente what may eventually be the largest mitigation reef in the United States (SCE 2004).

The study design and findings of the SONGS[1] reef pilot program are particularly relevant to the development of a reef construction program for the Montrose Settlements Restoration Program (MSRP). Although the primary goal of the SONGS reef program is to replace lost kelp forest

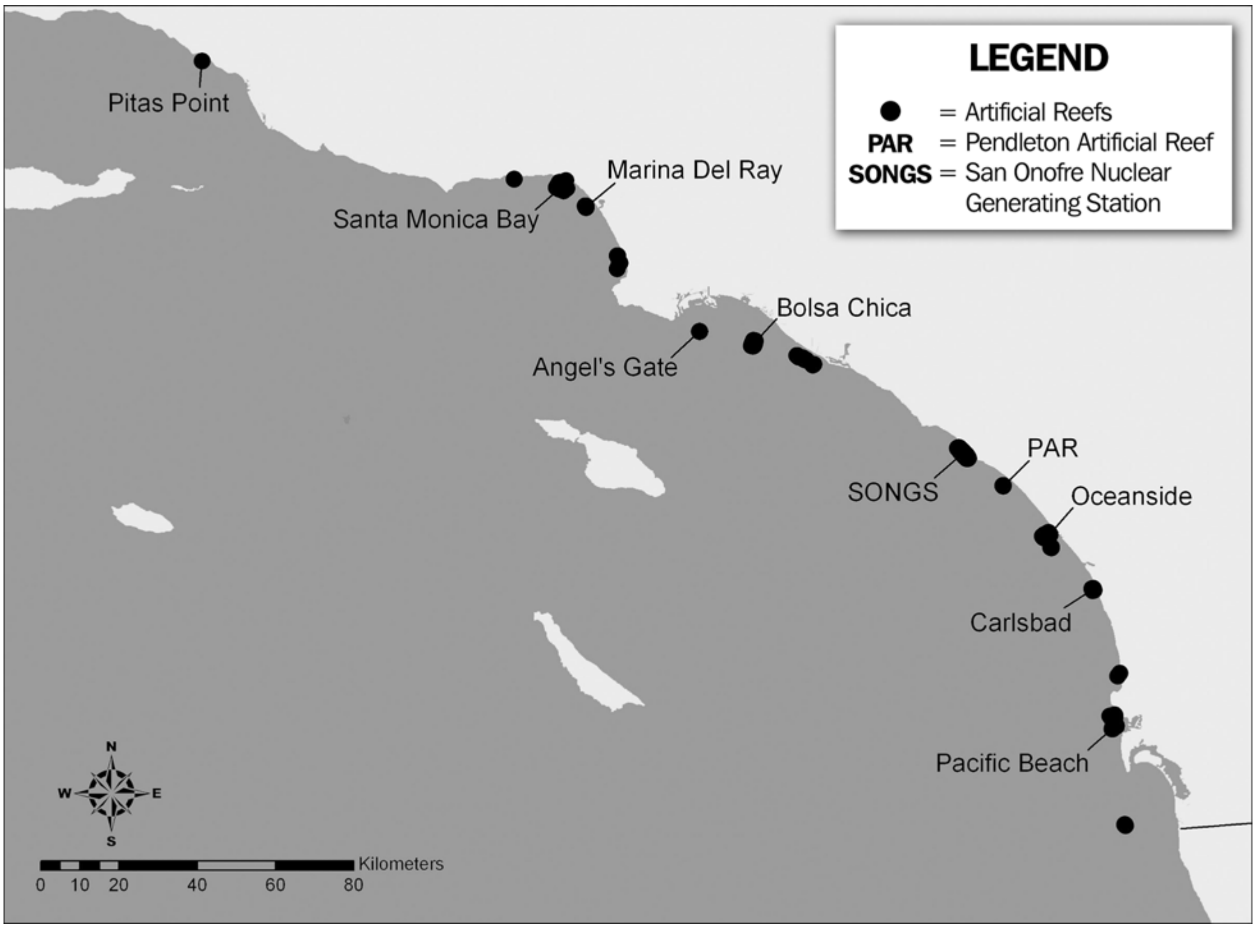


Figure A1-1. Artificial reefs in the Southern California Bight.

[1] Much of the information regarding the SONGS reef program is based on a phone interview with Dr. Steven Schroeter, who has been a principal investigator on the project since its inception.

habitat, the changes in fish community structure that occur would be relevant to the MSRP goal of providing cleaner fish for anglers. The utilities operating SONGS have developed a series of standards that the constructed reef must meet to achieve the desired level of mitigation and a 5-year pilot program to study how different reef designs perform in achieving these standards.

After reviewing the findings of previous studies, the SONGS parties designed and constructed an experimental modular reef system to investigate the importance of substrate (quarry rock versus concrete) and reef material coverage density (40 percent, 60 percent, and 80 percent) on kelp recruitment and growth as well as a more general analysis of community structure. Other issues evaluated in the SONGS pilot study will include the differences between high-relief and low-relief reefs (i.e., the variations in the sizes of the materials making up the reef), kelp out-planting versus natural recruitment, and several other considerations.

The SONGS 5-year evaluation study is scheduled to end in 2005. The Trustees will use the information generated by this and other developmental reefs to optimize the design of new artificial reefs to create a sustainable means for providing cleaner fish in the areas impacted by the contamination associated with the Montrose case.

A1.2.2 Designing for Sustainability

Artificial and natural reefs both attract fish and contribute to fish production under the right conditions (Ambrose 1994, Dixon and Schroeter 1998). Reef-based production can be estimated using several models, but most production estimates are based on estimating the standing stock on the reef at one or more points in time (Dixon and Schroeter 1998). Such estimates of changes in the overall biomass of fish do not differentiate between new fish production (i.e., gonadal production) and recruitment of fish from other areas (e.g., MEC Analytical Systems 1991).

For a constructed reef to add more fish to a total population, the fish population must be limited by the availability of reef habitat (Dixon and Schroeter 1998). Although it is uncertain whether fish populations are limited by the availability of reef habitat in Southern California, it is clear that reef habitat is rare relative to soft-bottom habitat (Cross and Allen 1993). Relative scarcity does not prove habitat limitation, but it is possible that building reefs will increase the number of potential settlement sites for juvenile reef fishes. Given the growing awareness that the settlement and early juvenile period is a significant mortality bottleneck for many marine fishes (e.g., Bailey and Houde 1989), particularly for reef-dwelling species (Victor 1986), an increase in potential settlement sites may increase survival through the early juvenile period.

The question of the relative importance of recruitment versus production remains unanswered for most marine reef fishes and for both natural and artificial reefs, but it is likely that both processes play a role (Dixon and Schroeter 1998). For example, certain artificial reef habitats in Southern California have supported self-sustaining populations of fish over more than a decade (Pondella et al. 2002) and have acted as a source of larval production that contributes significantly to the larval supply in the Southern California Bight (Stephens and Pondella 2002) However, the ability to confirm recruitment versus production is typically complicated by the high level of inter-annual variability in recruitment that occurs for most marine fish, the multiple recruitment bottlenecks that are likely to exist during early life history (e.g., first-feeding and settlement), and the difficulty in measuring the abundance of early-stage juveniles.

Because the focus of an MSRP reef program is to provide cleaner fish to anglers, the critical element is the degree to which the composition of fish species at a fishing site changes in favor of those that are less contaminated, rather than whether the reef increases the overall biomass of fish available. Nevertheless, the question of how reefs affect fish production is still relevant to this restoration effort, as the construction of new reefs may lead to increased local fishing pressure on fishing sites. This pressure could be addressed in a number of ways. A sufficiently large reef could be constructed to be sustainable despite the anticipated increase in fishing pressure. Alternatively, a reef could be placed in proximity to existing reefs where fishing is restricted or to Marine Protected Areas , thus incorporating into the reef design a source of fish to replace those caught at the fishing reef by anglers.

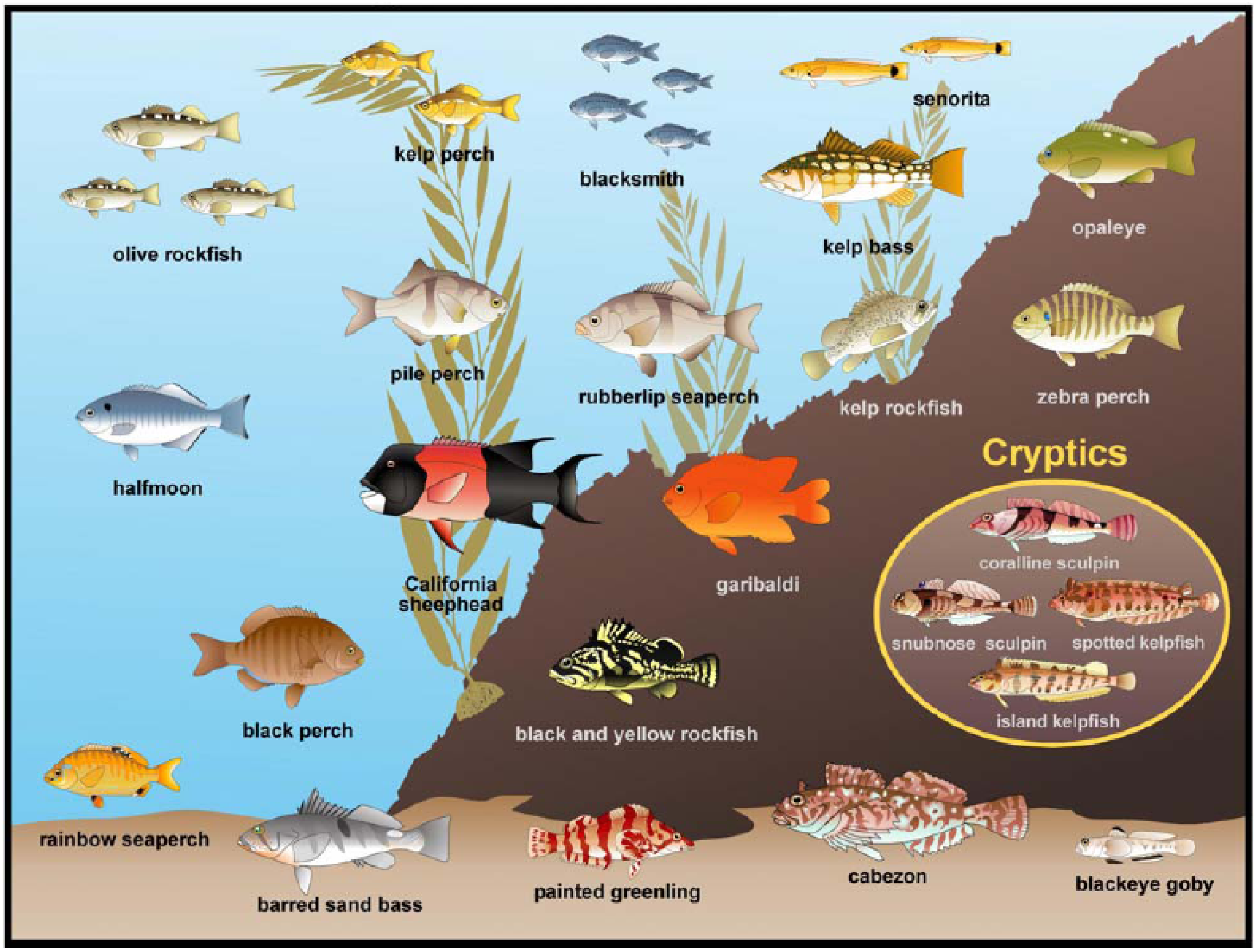
A fishing site enhancement program in Washington state provides one way of increasing the sustainability of fishing on artificial reefs. In 1974, the Washington Department of Fisheries began a marine fish enhancement program that involved building shore-based fishing structures (i.e., piers) and construction of "habitat enhancement" (reefs) around the structures to increase production/density of fish around them (Buckley 1982). These projects found that fishing structures that included habitat enhancement were much more productive and sustainable than those that did not. Also, the design of the enhancement was such that approximately 20 percent of the enhanced habitat was available to anglers using the fishing structure. The remaining 80 percent of the enhanced habitat was established as "production" zones and was protected against fishing from boats. This design resulted in sustainable fishing over a 50- to 10-year evaluation period.

The Washington study described a successional pattern in community structure where the reef community shifted from juveniles who appeared to be seeding unoccupied habitats to adults that appeared to be more resident. The conclusions of this study also suggested that the continuing availability of fish for fishing from pier structures was maximized via three mechanisms: (1) enhancement of the habitat surrounding structure to increase aggregation/production of fish; (2) episodic aggregation events producing periods of high catches; and (3) the presence of local resident fish that maintained catches during periods of low levels of aggregation. The third mechanism was promoted and sustained largely because significant components of the resident fish populations were protected from fishing.

Reefs can have substantial impacts on the local availability of fish that are lower in contamination. Although species that occur on a constructed reef are not the same as those that occur on soft-bottom habitats, constructed reefs support a diverse and productive community, and the species that occur on reefs perform many of the same ecological roles as those that occupy soft-bottom habitats (Ambrose 1994). Also, in a review of the literature pertaining to white croaker, Allen (1999) found that this species is never associated with any hard-bottom substrate, including natural or constructed reefs. Figure A1-2 is a schematic showing the fish assemblage associated with the rocky habitats adjacent to the Los Angeles breakwater (from Froeschke et al. 2005).

A1.3 PROJECT DESCRIPTION AND METHODS

The construction of artificial reefs and fishing access improvements is evaluated in this appendix at a non-site-specific, conceptual level for the MSRP Restoration Plan and programmatic Environmental Impact Statement/ Environmental Impact Report. The Trustees will further develop and design the details of the program as described below during the implementation phase of restoration and will prepare additional environmental documentation pursuant to the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) prior to final site selection and construction for each reef project.



(Source: Froeschke et al. 2005)

Figure A1-2. Fish assemblage adjacent to the Los Angeles breakwater.

The MSRP reef program will entail two types of activities. The first activity will be the construction of reefs to increase the availability of fish species that are lower in DDTs and PCBs. The second activity will be to implement improvements to fishing access and amenities to promote the use of the newly enhanced fishing sites, heighten awareness of the reasons why reefs were built in the vicinity of the fishing locations, and to act as compensatory restoration for past lost fishing opportunities.

A1.3.1 Reef Development

The development of the reef-building component will follow a five-step sequence: (1) contaminant and angler use evaluation; (2) site selection; (3) reef design; (4) reef construction; and (5) monitoring. This sequence is likely to be iterative, with some or all steps being applied to each constructed reef.

Step 1: Contaminant and Angler Use Evaluation

This step involves developing a detailed understanding of the spatial and species-specific patterns of contamination in the fishes commonly targeted by anglers in the Southern California Bight, and combining this information with information on fishing practices and preferences at different locations as obtained from surveys of anglers. This analysis will be guided by sediment contamination levels, as these levels will be the determiners of local resuspension of contaminants during reef construction and local bioaccumulation levels in the residents of the constructed reef.

The results of the fish contamination survey and the angler survey will be entered into a geographical information system (GIS) database to facilitate analysis and to generate a first-level evaluation of potential sites for reef construction. The fish contamination data will come primarily from the contaminant survey that MSRP is currently conducting in collaboration with the EPA; results are expected late in 2005. These results, coupled with those from the angler surveys that the State of California is conducting as part of the Marine Recreational Fishing Statistical Survey (MRFSS)[2] as well as those conducted by the Trustees and EPA in 2002 and 2003, will identify areas where high levels of angler activity are coupled with a large disparity between contamination levels in soft-bottom versus hard-bottom fishes.

Although detailed data identifying differences in contamination levels among species and locations are not yet available to conduct this analysis, evaluations of previous contaminant data (Figure A1-3) have been used to provide initial indications of likely regions for deployment of artificial reefs (Figure A1-4). Figure A1-3 displays historical data showing levels of contamination in three species of fish commonly collected in the Southern California Bight. At the time of these surveys, white croaker were contaminated above the State of California trigger levels (screening but non-regulatory concentrations of potential concern are indicated by the reference line in Figure A1-3) over a much broader geographic range than the other two species. These earlier data suggest reefs constructed in areas adjacent to the Palos Verdes Shelf may achieve MSRP restoration objectives (Figure A1-4). The updated and more detailed data will be

[2] The MRFSS in California is now an expanded program called the California Recreational Fishing Survey.

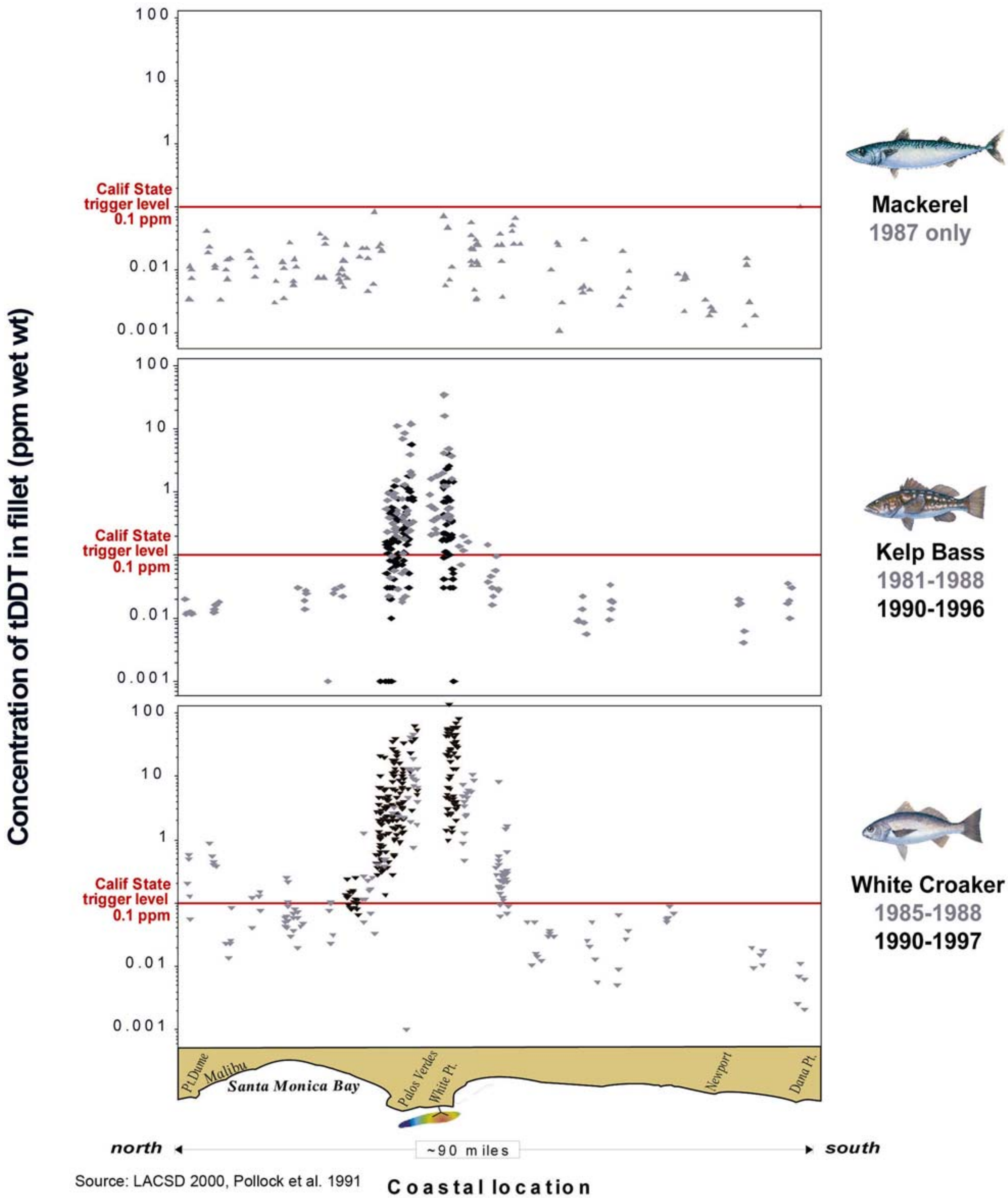


Figure A1-3. DDT in fish fillet between Malibu and Dana Point.

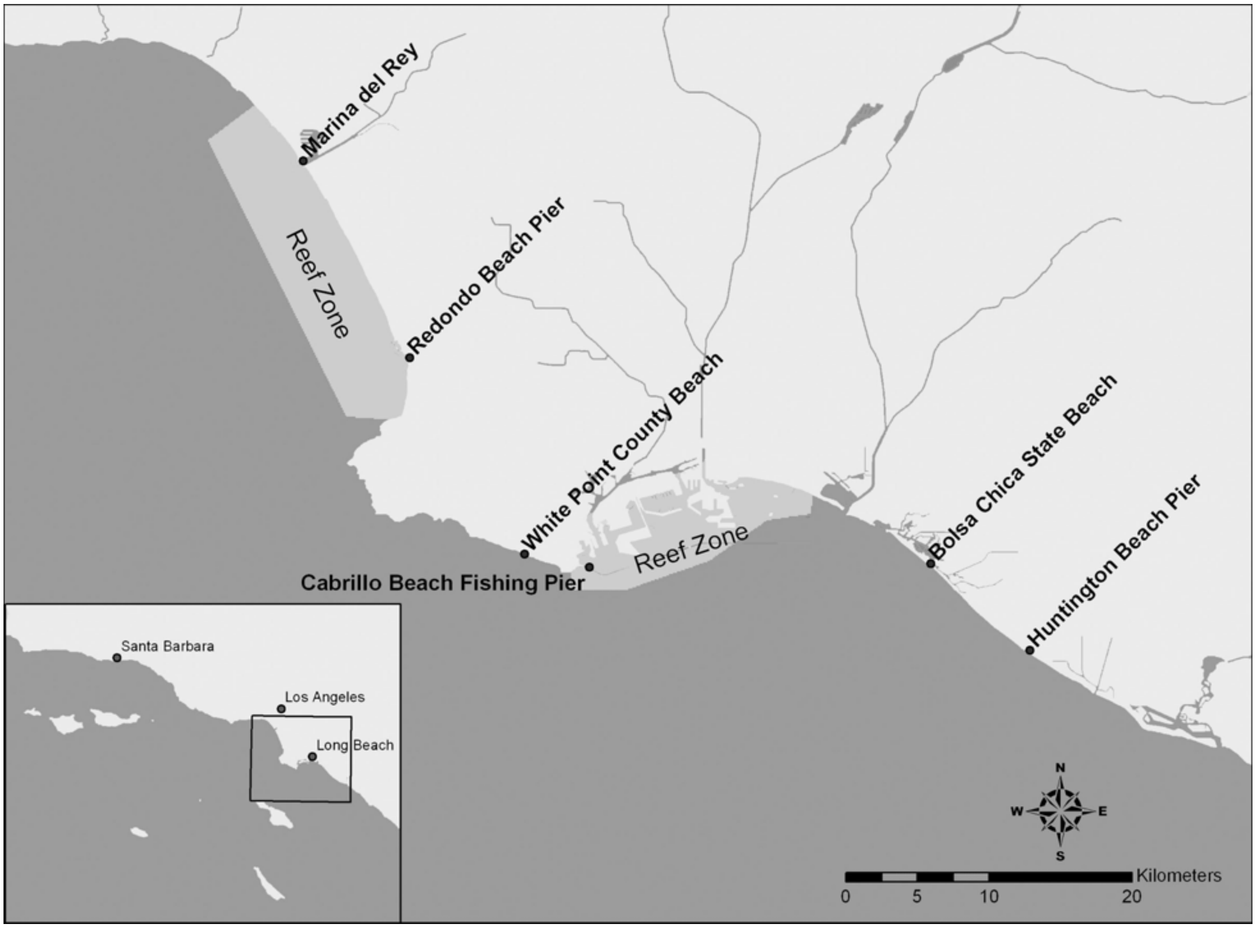


Figure A1-4. Potential zones for deployment of artificial reefs (indicated by gray-shaded areas).

used both to confirm the viability of these regions for restoration reef construction and to provide the detailed information necessary to determine specific project locations within the regions.

Step 2: Site Selection

In Step 2, the Trustees will refine and prioritize site and design considerations for individual reef projects, building on the broader site evaluation performed in Step 1. The Trustees will evaluate a comprehensive set of considerations, including:

- The potential effects of reef placement on sediment transport
- The suitability of the existing bottom substrate for placement of reef material
- The potential effects on navigation and recreational uses
- The presence of historically important sites
- The potential effects on essential fish habitat and species of concern
- The levels of local public support or opposition

- The proximity to other existing reef habitat or kelp beds
- The proximity to point-sources of pollutants (e.g., wastewater outfalls or storm drains)
- The potential for funding partnerships
- Current land management plans for the location.

The site identification step will involve an iterative proposal and review process; an initial list of a small number of candidate sites might be developed, publicly reviewed, and further refined. This step will include consultation with local jurisdictions and publicized workshops for interested parties to participate and comment on potential reef sites.

Placing new reefs adjacent to or sufficiently near existing similar habitat to allow for migration of fish from existing to new reefs will receive priority consideration. If new reefs are placed near existing reefs or kelp beds or are used to bridge gaps between existing isolated reefs, then the new reefs may generate benefits beyond those that would accrue from isolated reef construction. Such bridge or extension reefs could be designed to promote additional functions, such as the creation of nursery areas or the development of diverse reef habitats containing both high- and low-relief features, a range of depths, and structural complexity. Proximity to kelp forest habitats would increase the likelihood of natural recruitment of kelp to the constructed reef.

Shore-based fishing sites will receive highest priority, but offshore sites may be considered for fish production benefits. The justification for placing a higher priority on shore-based fishing sites is that anglers fishing from the shore or from piers generally have fewer choices regarding the habitats over which they fish than do boat anglers. The outcome of Step 2 will be a limited number of sites (e.g., two or three) to carry forward into subsequent steps.

Step 3: Reef Design

Step 3 will determine the final form of the constructed reefs. This step will incorporate results from past and ongoing artificial reef evaluation projects (e.g., the Pendleton Artificial Reef and SONGS), the input of experts in the field, and the limitations associated with the specific reef site identified in Step 2. Considerations to address include material type, the nature of existing sediments in the area, amount of relief, patchy versus even coverage, kelp outplanting versus reliance on natural recruitment of kelp, the fraction of the reef that would be available to anglers for fishing versus the fraction that would be less available or specifically protected for production, and the connections with existing artificial or natural reef habitats. Step 3 will also design the pre- and post-construction monitoring that will take place to determine the effectiveness of the restoration effort. The final result of this step will be supplemental NEPA and CEQA documentation for one or more individual reef construction projects; this documentation will be released for public comment. After public comments are incorporated, permit applications will be submitted.

Step 4: Reef Construction

Step 4 will be initiated after the acquisition of appropriate permits and final design work, including identification of specific construction methods and sources of materials, determination of the contracting and construction management approaches, and establishment of funding partnerships. For planning purposes the Trustees anticipate constructing reefs at two to three locations over a 5-year period.

Step 5: Monitoring and Long-Term Oversight

The purpose of monitoring a constructed restoration reef is to document the abundance, species composition, size frequency, and contamination levels of the fishes that occupy the reef as the community develops. The following discussion provides a template for the fish contaminant component of the monitoring that can be applied to any MSRP reef project. The monitoring of species composition, abundance, and size structure will follow the protocols established as part of the long-term shallow subtidal fish monitoring programs in other parts of California (e.g., the Partnership for Interdisciplinary Studies of Coastal Oceans and the National Parks Service kelp forest monitoring survey).

The Trustees have two fundamental incentives for collecting fish contaminant data from a restoration reef. The first incentive stems from the likelihood that MSRP will be building reefs sequentially rather than simultaneously. Thus, the information on fish species abundance, species composition, and contamination levels gained from one reef project could be applied to the design and location of future reef projects. In this way, the MSRP reef program will be implemented using an adaptive management strategy to maximize the positive impacts of each constructed reef.

The second incentive for monitoring fish contamination levels is that the Trustees will provide empirical confirmation that the reef has improved fishing by increasing opportunities to catch less-contaminated fish. There is good reason to believe that the fish that occupy the constructed reef habitat immediately after construction may differ in contamination levels from those that occupy the reef later because of the successional nature of community development on created reefs. The early inhabitants of a constructed reef are almost entirely transient individuals that move in from other areas and that may reflect bioaccumulation rates in areas adjacent to the reef site. The proportion of resident individuals that reflect bioaccumulation rates more local to the site typically increases as time passes. The monitoring of restoration reefs should reflect the need to estimate contamination levels in fish in both the short term and the longer term.

Contaminant monitoring will cover a suite of species that represents the diversity of eco-types targeted by local anglers. Southern California is home to a diverse assemblage of fishes, and anglers target many of these fish. For example, in 2003 anglers in Southern California reportedly landed over 120 species of fish (RecFin 2005). This taxonomic diversity encompasses a diversity of foraging modes, home ranges, and habitat associations, even within the subset of fish species that frequent reef and hard-bottom habitats. The proposed contaminant monitoring scheme will encompass this diversity by sampling representative species that forage at different trophic levels and are associated with different microhabitat types.

The Trustees plan to adopt a strategy of partnering with other agencies and organizations to obtain pilot-level information on reef designs and placement. This strategy will result in the greatest benefit in terms of achieving MSRP restoration goals. For example, a partnership opportunity exists in a reef project that the Port of Los Angeles (POLA) has proposed off of Point Fermin. The application of the reef-fish contaminant monitoring program to the proposed POLA reef would benefit the MSRP reef planning efforts in at least two ways. First, the POLA reef deployment is likely to occur before any MSRP reef construction. Thus, the fish contamination data from the POLA reef would be available to assist in the siting and design of the MSRP reefs. These data would provide indications of contaminant levels in the fish that in succession occupy such a reef and might be useful in obtaining public acceptance and permitting for MSRP reefs sited in similar areas with transitional levels of sediment contamination.

Second, reef monitoring for the POLA project will also document whether and how fishing practices have been affected by the project. Thus, surveys of anglers will be conducted to determine the effects of the project on fishing practices and preferences. These surveys will identify the fish being caught by anglers and retained for consumption before and after reef construction. This information will aid the Trustees in their efforts to design and construct reefs that have positive fishing benefits.

In the long term, it is anticipated that MSRP-constructed reefs will become part of the existing California artificial reef program, which is administered by the California Department of Fish and Game (California Fish and Game Code Sections 6420–6425).

A1.3.2 Fishing Access Improvements

During the reef development steps outlined above, the Trustees will also consider whether the improvements to fishing access and amenities at the sites under consideration for reefs would complement the restoration of lost fishing services. Several types of improvement will be considered, including parking improvements, construction or extension of piers to ensure optimal fishing access to constructed reefs, and increases in the number of or improvements in fish cleaning stations, lighting, benches, railings, restroom facilities, etc. Interpretive signs, displays, kiosks, or other materials may also be provided to explain to the public the need for and the function of the fishing restoration actions. Consideration and evaluation of improvements to access and amenities at these locations will be conducted in parallel with reef site design and development and will entail close consultation with local and state jurisdictions and interested users.

The Trustees have conducted preliminary analysis of the cost of pier construction and the construction of associated amenities. The unit cost of pier construction appears to be on the order of $200 per square foot or more; thus, the cost of constructing a pier of 50,000 square foot would likely exceed $10 million. Because MSRP restoration funding is limited and the primary objective of this restoration approach is reef construction, the Trustees would likely place a cap on the proportion of funding devoted to access improvements to ensure that sufficient funds are available for reef construction.

A1.4 ENVIRONMENTAL BENEFITS AND IMPACTS

This analysis addresses the environmental consequences of constructing artificial reefs and fishing access improvements at a broad conceptual level, as no specific sites have been proposed or evaluated. Additional NEPA and CEQA documentation will be required to address site-specific environmental considerations.

A1.4.1 Biological

Benefits

Reefs provide habitat for a multitude of marine fishes, invertebrates, and plants. The displacement of the sandy or muddy bottom habitat with a hard-bottom substrate would increase the diversity and may increase the number of the animal and plant biota in the area. Reefs act as nursery and spawning habitat for a variety of species native to the Southern California Bight. Reefs also act as a substrate for the recruitment and growth of giant kelp, which are also an important component of critical nursery habitat for many fish and invertebrate species. In addition, the fish productivity of rocky reef habitat has been estimated to be between 9 and 23 times that of sandy bottom habitat (MEC Analytical Systems 1991).

Recent declines in certain species of groundfish on the west coast, including rockfish complexes, have led to increased restrictions on fishing for these species. To the extent that reefs constructed under the MSRP program function as production sites for these or similar species (e.g., should reef design include a fish production/nursery component that increases the abundances of rockfishes), reefs may benefit the management and recovery of these depleted species of fish.

Because reef-associated fish typically contain lower concentrations of DDTs and PCBs than soft-bottom species, constructed reefs would benefit the biological organisms that prey on fish in the vicinity of the constructed reefs, as the organisms preying on fish would be exposed to reduced levels of these contaminants.

Once constructed, an artificial reef would provide benefits for many decades with minimal operational and maintenance costs.

Impacts

In general, hard-bottom or reef habitat is one of the most important but least abundant habitats in the Southern California coastal marine environment (Cross and Allen 1993). Soft-bottom substrates (i.e., sand and mud) predominate in an overwhelming percentage of the marine area along the coast from Point Dume to Dana Point (Ambrose 1994). Thus, conversion of habitat from soft-bottom to reef on the scale feasible under this restoration program would not significantly reduce the total available soft-bottom habitat to those species that rely on it. It is possible that constructing reefs may impact the availability of some other limited inshore habitat or resource, such as eelgrass beds. Also, soft-bottom habitat in nearshore waters of California are spawning areas for market squid (*Loligo opalescens*), which is an important commercial species in California. In addition, sheltered, shallow soft-bottom areas in certain locations (e.g., inside the Los Angeles and Long Beach Harbor breakwaters) provide important nursery areas for several fish species, including California halibut. The specific locations of each constructed reef will be studied and selected such that limited natural habitats are not covered or compromised.

Artificial reefs are known to be aggregators of marine life; such sites are popular fishing and diving locations because of the large numbers of fish and invertebrates attracted to the structures for habitat and food. Because of the popularity of these sites for anglers, fish mortality could increase in the vicinity of newly constructed reefs. Such an effect might also occur as a result of improvements to fishing access and amenities that increase the number of fishing trips to a site. Thus, before a reef is constructed at a given site, appropriate steps will be taken to ensure that reef design, size, placement, and long-term management will accommodate the anticipated increases in fishing and other uses of the reef site.

At a conceptual level, reef construction projects are not likely to adversely affect threatened or endangered species or essential fish habitat. However, detailed analysis will be performed at a site-specific level before a reef is constructed.

A1.4.2 Physical

Benefits

The benefits of artificial reefs to the physical environment would be nominal. To the extent that the material used to construct a reef is taken from the demolition of concrete structures, the beneficial reuse of this material would divert it from land disposal and conserve a corresponding increment of landfill space. Other trade-offs related to the transportation and disposal of materials (such as reduced air quality impacts relative to land disposal) would occur, but whether they would have net positive or net negative consequences cannot be determined until site-specific implementation factors are determined.

Impacts

The placement of reefs in nearshore areas has the potential to alter the transport of sediment and affect the topography of adjacent subtidal and beach areas. Also, depending on the nature of the soft substrate in a given area, the depth to bedrock, and the slope, hard substrate dropped to the marine bottom may not perform as intended. The potential physical impacts from placing rock or rubble in a given area will be submitted to engineering analysis and supplemental review and evaluation performed.

The placement of concrete or rock materials into marine waters would cause short-term suspension of sediments at the site and result in short-term water quality impacts. The principal effect would be increased turbidity; however, depending on local conditions, the sediments at the reef site might contain elevated contaminant levels. The methods and timing for reef material placement may be adjusted in consultation with regulatory agencies to address such local conditions and reduce the short-term water quality impacts of the construction.

A1.4.3 Human Use

Benefits

Artificial reef construction in areas will displace highly contaminated soft-bottom species and replace them with less-contaminated hard-bottom and water-column species. This result will provide direct benefits to anglers whose fishing opportunities have been impacted by fish consumption advisories. Artificial reefs provide human use benefits beyond fishing, as they are also popular areas for scuba and free diving for purposes of recreation, hunting, and underwater photography. As with the biological benefits, the human use benefits will be sustained for a period of decades or longer with minimal operational or maintenance costs.

Improvements to fishing access may include the addition of various fishing site amenities, including fish-cleaning stations, benches, pier extensions, or parking improvements. Informational panels or kiosks might also be included at reef sites to inform and educate the public on the benefits of the project. Such improvements will be undertaken with the specific intent of improving human use at the fishing site, thereby compensating for past and ongoing lost fishing opportunities, and efforts will be made to ensure functional and aesthetic benefits.

Impacts

Depending on its location and design, an artificial reef can impact various human uses in an area. Potentially impacted uses include recreation (e.g., board, body, or wind surfing) and navigation. Constructed reefs displace soft-bottom species, so the anglers specifically targeting these species at the site would find it harder to catch these fish. The potential impacts to recreational and navigational uses will be a significant consideration as candidate sites are evaluated. One of the purposes of the survey of recreational and subsistence anglers that the Trustees undertook in 2002 and 2003 was to determine fishing preferences at fishing sites along the Los Angeles and Orange County coast. The data generated by this field intercept survey and the follow-up public involvement activities will be used to select sites that minimize negative impacts to anglers who may be exclusively targeting soft-bottom fishes. The survey findings will be included in subsequent site-specific environmental documentation that will be developed by the Trustees. It is unlikely that a reef will be constructed in an area used by surfers (e.g., in high-energy surf areas) because of the tendency of swells and waves to damage or destroy artificial reefs.

Construction activities at fishing sites (e.g., construction improvements to piers and the provision of amenities such as fish cleaning stations, parking, etc.) may cause short-term disruption to users of a site during the period of construction. Steps will be taken to minimize the impacts of construction; these steps will be addressed at the stage when site-specific plans are being considered.

A1.5 LIKELIHOOD OF SUCCESS/FEASIBILITY

Artificial reefs have been constructed in many areas along the coast of California and elsewhere to enhance fisheries and fish production and to replace lost habitat. Studies of previously constructed reefs (including the 5-year pilot reef project near San Clemente) have resulted in a substantial body of knowledge on the likely outcomes associated with different design attributes and implementation approaches. Although the principal purpose for an MSRP reef (i.e., displacing highly contaminated fish and attracting/producing less contaminated fish) may be novel, the likelihood is high that constructing reefs in suitable areas will achieve this purpose. Sufficient data are available to develop reasonable predictions about species abundance and composition in a constructed reef. The degree to which the changes in species composition will lower the contamination levels in the fish caught by anglers at a site can be predicted from measurements of contaminants in similar fish caught near the potential reef sites. Thus, it is feasible to design and place a reef to achieve this purpose; it is also feasible to scale the reef such that it will provide sustainable fishing services.

Appropriately placed artificial reefs increase the diversity of the local marine ecosystem and often attract increased recreational use. Where complemented with above-water enhancements (e.g., improvements to fishing access and associated recreational amenities), reefs are well suited for the goals of both restoring and compensating for lost fishing services.

Several potential reef sites exist within the regions indicated in Figure A1-4. The Trustees have not proposed specific reef sites at this stage. Rather, the Trustees will allocate funds for artificial reef construction and associated fishing access improvements. Selection and design of specific projects will be decided through further analysis, planning, and public review of site-specific proposals. In this context, the Trustees will seek to enter into partnerships with other parties willing to co-fund such work to leverage the use of natural resource restoration funds to obtain as many acres of new reef habitat as possible within the limits of available funding.

Regulatory approval and public acceptance of reef construction projects have been achieved in the past. However, recent efforts by POLA to obtain approval to construct a new artificial reef offshore of Point Fermin have been delayed pending resolution of concerns about the proximity of the site to contaminated sediments on the Palos Verdes Shelf. This case suggests that any proposal to construct a reef for the MSRP objective of displacing contaminated fish will require careful planning and coordination with interested parties. Nevertheless, there is general support for reef construction. Fishing organizations such as the United Anglers have expressed a desire for more artificial reef construction, and regulatory agencies have approved reef construction as a means for mitigating environmental impacts.

A1.6 PERFORMANCE CRITERIA AND MONITORING

Several performance criteria will be used to evaluate the effectiveness of a constructed artificial reef in meeting the Trustees' restoration goals: fish abundance, species composition, fish size distribution, and the fish contamination levels. Abundance and size distribution are important because an increase in fishing services requires sufficient abundances of legal-size fish to replace the displaced soft-bottom fish that occupied the fishing area prior to reef construction. The contamination levels in the fish that occupy the reef are clearly important because the goal is to increase the local abundance of cleaner fish. Each of these parameters may undergo a successional sequence after reef construction, so it will be necessary to implement a monitoring program that includes high temporal resolution (e.g., annual or biannual) monitoring initially followed by more infrequent monitoring later to determine the sustainability and stability of the reef community.

A1.7 EVALUATION

The Trustees have evaluated this restoration action against the screening and evaluation criteria developed to select restoration actions and have concluded that this action is consistent with these selection factors. This action will address the loss of natural resource services provided by fish, which was one of the natural resource injuries brought forward by the Trustees in the Montrose case. Species composition and the contamination levels of the fish occupying the reef site can be measured prior to and after reef construction and the net change in the availability of cleaner fish can be estimated by combining species distribution with species-specific contamination levels. Artificial reef construction has been shown to have pronounced local effects on species composition through the combined effects of production and attraction, so a reef is highly likely to produce local changes in species composition. Thus, larger-scale (i.e., regional) increases in population levels will not be required to have the desired restoration effect.

This action will require supplemental environmental documentation that will be prepared after development of site-specific proposals pursuant to NEPA and CEQA.

A1.8 BUDGET

The Trustees have previously developed estimates of the cost and amount of artificial reef needed to replace the contaminated biomass of fish caused by the Montrose contamination (Ambrose 2000). These estimates ranged from $60,000/acre to $318,000/acre based on the construction of 1 to 9 acres of reef. This analysis revealed that the smallest reefs (1 to 2 acres) had by far the greatest per-acre construction costs ($318,000 and $250,000 per acre for the smallest and second smallest reefs, respectively). This estimate is subject to substantial variability due to several unknowns, such as the purchase cost of materials for reef construction. Furthermore, the density of reef material contributes substantially to the costs associated with reef construction. The SONGS reef project experienced a 20 percent decrease in construction costs between its high-density and its low-density reef treatments. The results of the SONGS analysis may help to identify the most cost-effective design for MSRP reefs.

This restoration program will proceed incrementally, with a goal of constructing two to three reefs in the 5-year period during the first phase of restoration. The costs of such a program may be broadly estimated as follows:

- Reef design, permitting, construction, and monitoring: Ambrose (2000) estimated an average cost of $170,000 per acre. Assuming 10 to 12 acres of coverage for each reef, each reef project would cost $1 million to $2 million. The 22.4-acre artificial SONGS reef cost $2.7 million to construct, suggesting construction costs of approximately $120,000 per acre.

- Construction of fishing access improvements: The cost of this construction has been estimated based on several potential actions that could be implemented at a number of fishing sites (MSRP Administrative Record). The estimated costs associated with building a new pier are approximately $200/ft^2, so the total cost of building a new pier that is similar in size to other piers in Southern California (e.g., the Redondo Pier, which is 70,000 ft^2) would be approximately $14 million. Thus, matching funds would be critical for undertaking such a project. The cost of installing access improvements to existing piers has been estimated to range from $92,000 to $368,240 depending on location and the needed improvements.

The two estimates cited above suggest a potential range of costs for each reef and access project of $2 million to $4 million.