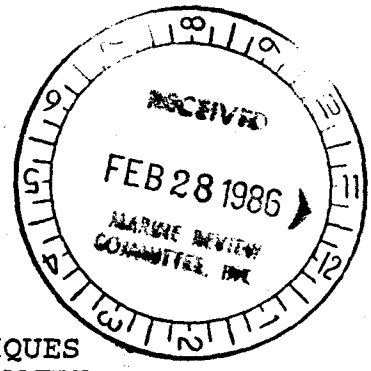

AN EVALUATION OF ALTERNATIVE TECHNIQUES FOR MITIGATING IMPACTS OF THE SAN ONOFRE NUCLEAR GENERATING STATION

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EXECUTIVE SUMMARY

This report presents an overview of options available for mitigating the possible effects of the San Onofre Nuclear Generating Station (SONGS), and evaluates the appropriateness of each option. The three types of mitigation techniques considered are: (1) those replacing lost resources with identical resources (in-kind compensation), (2) those substituting different resources for the lost resources (out-of-kind compensation), and (3) those avoiding or minimizing the loss of resources (loss prevention).

Mitigation is a process designed to minimize the loss of resources or compensate for unavoidable resource losses that result from human activity. The ultimate objective of the mitigation process is to maintain the functional and productive capacity of the ecosystem, while accomodating necessary development of natural resources. The U.S. Fish and Wildlife Service has an official mitigation policy that establishes the framework for mitigation and prioritizes mitigation planning goals on the basis of the value of the resource; in California, the other government agencies involved in mitigation in the marine environment follow the same general philosophy as FWS.

The fundamental principles guiding the FWS policy are that avoidance or compensation be recommended for the most valued resources, and the degree of mitigation requested correspond to the value and scarcity of the resource at risk. Two different kinds of mitigative compensation are recognized: <u>in-kind</u> replacement of

resources involving resources that are physically and biologically similar to those being altered and that play similar roles in ecosystem function, and out-of-kind substitution or resources involving dissimilar resources. The most preferred type of compensation is in-kind replacement of species at the location of the impact ("on-site"). The FWS mitigation policy focuses on losses of "habitat value". However, a broader perspective may be necessary to evaluate mitigation in an open coast ecosystem.

In-kind replacement of resources that are lost due to the operation of SONGS might be accomplished by enhancing existing kelp beds, creating new kelp beds, constructing artificial reefs, constructing fish hatcheries, restoring fish nursery habitats, constructing invertebrate hatcheries, or manipulating natural habitats. In-kind replacement of resources is the most preferred method of compensation, so these techniques should be considered for the majority of the resources and/or the most valuable resources. The techniques that seem best for application at SONGS are (1) creating a kelp bed, and (2) constructing an artificial reef.

Out-of-kind substitution of lost resources could be accomplished by any of the in-kind techniques, or by habitat (especially wetland) restoration or enhancement, preservation of coastal lands, information acquisition, or water quality improvement. For resources that cannot feasibly be replaced by in-kind techniques, out-of-kind techniques must be used to achieve compensation. The three out-of-kind techniques that seem best for

application at SONGS are (1) restoring or enhancing a habitat, (2) acquiring information, and (3) acquiring and preserving coastal land.

The prevention of resource losses is generally the most favored technique for mitigation. However, loss prevention techniques at SONGS cannot be integrated into project planning or construction. Two loss prevention techniques, the Fish Return System and velocity caps, have already been implemented at SONGS. Implementing other techniques involving structural changes to SONGS would involve unknowns in the areas of engineering, biological effects, and economics. Two loss prevention techniques that do not require structural changes are: restricting the flow rate of water through the cooling system, and shutting down operations during seasons of high potential impact. It is not clear that seasonal restriction of operations would be effective at SONGS.

There are many unknowns associated with the techniques discussed in this report, making it difficult to evaluate their feasibility for use at SONGS. I have recommended three studies that will assess the feasibility of the most promising mitigation techniques. First, I recommend studying the feasibility of creating kelp beds. Techniques used for establishing kelp and the potential of different locations could be evaluated. Second, I recommend studying the production of fish on artificial reefs. The relationship between fish production on natural versus artificial reefs could be investigated by surveys of natural and artificial reefs. Additional studies of Pendleton Artificial Reef would also

be useful, and the MRC might consider becoming involved in the planning and monitoring of large-scale experimental reefs to be built by the Department of Fish and Game. Finally, I recommend determining the critical life stages of fish species at risk at SONGS. Identifying potential life-history bottlenecks through a detailed review of existing information would aid in evaluating the feasibility of utilizing fish hatcheries or restoring nursery habitat to compensate for fish losses. Finally, I note that the lack of information about possible mitigation techniques is a significant obstacle to evaluating their feasibility, yet previous mitigation efforts have not been studied closely. I suggest that, regardless of the technique(s) chosen, the MRC recommend appropriate evaluative studies be conducted.

A glossary of terms related to mitigation is included.

PREFACE

The Marine Review Committee has been charged with determining the effects of the cooling system of the San Onofre Nuclear Generating Station (SONGS) on the surrounding marine biota. Initially, the aim of the MRC was to provide information to the California Coastal Commission (CCC) concerning possible changes in the cooling system of SONGS to prevent or reduce any adverse effects to the marine environment. In 1979, the Commission recognized that some effects might be mitigated without requiring changes in the cooling system, as indicated by the following excerpt from staff recommendations (Fischer 1979): "The Commission also recognizes that operational changes or mitigation measures might adequately compensate for any marine life damages resulting from the operation of Units 2 and 3. The Commission, therefore, requests the MRC to study the feasibility and effects of selected promising mitigation measures, including construction of an artificial reef, as suggested by Southern California Edison. The MRC should recommend what measures might be taken to assure there would be no net adverse effect on the marine environment from operation of SONGS Units 2 and 3." The MRC began investigating alternate mitigation measures in 1980. In 1984, the Commission requested (Tobin, June 8, 1984) that the MRC "review the work done to date on mitigation and determine if any additional mitigation research is appropriate. At the end of MRC study, the committee

should be able to recommend sound, feasible mitigation measures for project impacts."

0.1 Purpose of this report

The present project, "A Study of Mitigation", was undertaken to summarize the relevant work on mitigation in the marine environment and to evaluate the information on potential mitigation techniques as they relate to SONGS. The project has had two tasks, each resulting in a report to the MRC. The first task was to review and summarize existing information on artificial reefs in order to evaluate the feasibility of using artificial reefs as a mitigation technique. The artificial reef report, including a bibliography, has been submitted to the MRC. The second task was to identify other techniques for mitigating the possible effects of SONGS; this is the subject of the present report.

The object of this report is to present an overview of options available for mitigation at SONGS, and to evaluate the appropriateness of each option. The report is in two parts. The first provides a general overview of mitigation, particularly as practiced in California. It also provides a summary of predicted impacts of SONGS. Because the MRC's studies of the impacts of SONGS have not been completed, this summary is based on predictions made by the MRC at the conclusion of its pre-operational studies (MRC 1979) and more recent reports by MRC contractors. Although the summary of impacts of necessity must remain non-specific at this time, it does identify the general types of resources that may

need mitigation. The second part presents specific mitigation techniques that could be considered for SONGS. These techniques are organized by the type of compensation they provide, e.g. in-kind replacement of resources or out-of-kind substitution of resources.

0.2 Previous work on mitigation by the MRC

The following earlier reports have been submitted to the MRC as a result of work directly related to mitigation:

> Sheehy, D. 1981. Artificial reefs as a means of marine mitigation and habitat improvement in Southern California. Report to the Marine Review Committee, Jan. 27, 1981. Aquabio, Inc., Columbia, Md. 68 pp.
>
> Thum, A., J. Gonor, A. Carter and M. Foster. 1983. Review of Mitigation: Final Report. Report to the Marine Review Committee, Dec. 21, 1983. 78 pp.
>
> Ambrose, R.F. 1985. Artificial Reefs. Volume I: A Review and Analysis. Volume II: Bibliography. Draft report to the Marine Review Committee, Sept. 1985. 165 pp. and 109 pp.

The report by Sheehy (1981) primarily summarizes various techniques used in Japan to enhance marine fisheries, although it also discusses how these techniques could be applied to mitigate losses that might be associated with SONGS. The report by Thum *et al.* (1983) provides a brief overview of state and federal requirements for proper mitigation, a case history of mitigation of the environmental effects of intertidal dredging and filling of estuaries in Oregon, and a review of mitigation legislation in California. Thum *et al.* also discuss the results of the Pendleton

Artificial Reef project, and suggest some alternative methods for utilizing artificial reefs as a means of mitigation. As discussed in the previous section, the report by Ambrose (1985) reviews information on artificial reefs in order to evaluate the feasibility of using artificial reefs as a mitigation technique. Note that all three of these reports have focused on artificial reefs as a mitigation technique.

The MRC has also undertaken projects involving kelp, halibut, and biological community development on an artificial reef. The effectiveness of the Fish Return System has also been evaluated. Some of the relevant reports for these projects are listed below.

Lockheed Ocean Science Laboratories (LOSL). 1983a. Pendleton Artificial Reef, Benthic and fish community development, September 1981-November 1983, Final Report, Volume I. Report to the Marine Review Committee.

Lockheed Ocean Science Laboratories (LOSL). 1983b. Pendleton Artificial Reef, Pterygophora transplantation study, Final Report, Volume II. Report to the Marine Review Committee.

Lockheed Ocean Science Laboratories (LOSL). 1983c. Succession on Pendleton Artificial Reef: An artificial reef designed to support a kelp forest, Final Report, Volume III. Report to the Marine Review Committee.

Allen, L.G., C.P. Onuf and M.S. Love. 1984. Results of a pilot study on the distribution and abundance of young-of-year California halibut in the vicinities of Alamitos Bay and San Onofre-Oceanside, May-June, 1984. Report to the Marine Review Committee.

DeMartini, E.E. 1985. Updated evaluation of fish diversion and preliminary estimates of annual fish losses at SONGS Units 2 and 3. In: April 1985 Year-End Report of the UCSB Fish Project. Report to the Marine Review Committee.

Although all of the preceeding reports have dealt with some aspect of mitigation, the scope of each report has been limited. In addition, most of the reports, even Thum et al.'s "Review of Mitigation", have focused on artificial reefs. The present report is the first to present a variety of different techniques that could be considered for mitigating the effects of SONGS.

CHAPTER 1

INTRODUCTION

1.1 Mitigation

Many development projects result in environmental impacts. Without preventative or remedial action, the cumulative effects of many projects would result in a serious degradation of the environment. A number of different actions have been undertaken in the United States to prevent or reduce environmental degradation while still allowing rational use of our natural resources. Mitigation is one action that can be used as a positive management tool to maintain environmental quality while allowing resource use.

1.1.1 Definition and general application

The concept of mitigation is straight-forward: reducing adverse impacts of a project, and compensating for unavoidable impacts, can prevent a net deterioration of the environment.

Although the concept of mitigation is simple, until recently there has been little agreement on what mitigation actually involves. Because there has been no generally accepted definition of mitigation, and because different government agencies have had different goals and perspectives, the application of mitigative actions to different development projects has been uneven. The National Environmental Policy Act (NEPA) attempted to rectify this situation by providing a standard definition of mitigation.

Mitigation, as defined in NEPA (40 CRF, Section 1508.2), consists of:

a. avoiding the impact altogether by not taking a certain action or parts of an action;

b. minimizing impacts by limiting the degree or magnitude of the action and its implementation;

c. rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

d. reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;

e. compensation for the impact by replacing or providing substitute resources or environments.

Since this definition applies to all federal activities and all types of environmental resources, the Fish and Wildlife Coordination Act (FWCA) has adopted a definition directed specifically at fish and wildlife resources:

> "Mitigation" means (a) lessening wildlife resource losses to a project through loss prevention measures and (b) offsetting losses through the use of other structural and nonstructural measures.
>
> "Loss Prevention" means designing and implementing a project to avoid adverse impacts upon wildlife resources.
>
> "Compensation" means completely (i.e. 100%) offsetting losses to wildlife resource values. . . .

The USFWS has also been concerned with mitigation, since they are the federal agency that is primarily charged with evaluating impacts on wildlife. The Fish and Wildlife Service and other agencies serve primarily as consultants for the agencies providing permits for projects that may require mitigation. The permitting

agencies are required to give great weight to recommendations by FWS. In 1981, FWS published their official Mitigation Policy; a copy of this policy is included in Appendix 1. The stated purpose of the policy is "to protect and conserve the most important and valuable fish and wildlife resources while facilitating balanced development of the Nation's natural resources" (USFWS 1981, p. 7644; see Appendix 1).

The primary focus of the USFWS policy is the mitigation of losses of "habitat value" (USFWS 1981, p. 7645; see Appendix 1). FWS defines habitat value as "the suitability of an area to support a given evaluation species." The FWS feels that habitat value, by measuring carrying capacity of the species of interest ("evaluation species"-see Glossary), is a better basis for determining mitigation requirements than population estimates. The focus on habitat value seems to work well for terrestrial ecosystems. As an illustration, consider the consequences of developing a forest that is inhabited by a population of deer. Although the development itself would not kill the deer, the area would lose its capacity to produce deer. Restoring the habitat value by producing a similar forest, either on the same site or elsewhere, would restore the capacity of the ecosystem to produce deer. The FWS recognizes that mitigation of population losses per se may sometimes be necessary. For example, mitigation might be required when dam construction on a salmon river blocks migration routes, even though habitat value is not affected. Nonetheless, FWS believes that mitigation of

impacts on habitat values will be sufficient in the majority of cases.

USFWS has devised the Habitat Evaluation Procedures (HEP) to aid in quantifying the value of impacted habitats, and to provide an objective method for evaluating alternative methods of habitat management. HEP is described in more detail in Appendix 2. Although HEP is gaining wide use in terrestrial habitats, its use is still preliminary, and in many cases inappropriate, in the marine environment. Current activities of the National Coastal Ecosystems Team of Fish and Wildlife focus on species that occur in estuaries and coastal wetlands, with no plans to become involved in marine applications (Appendix 3). Even though the formal Habitat Evaluation Procedures have not been applied in marine systems, a modified version of HEP has been; the modified version uses the "best professional judgement" of local experts to estimate habitat value (J. Fancher, personal communication).

Although the Fish and Wildlife Service has not been applying the formal HEP approach in the marine environment, their general mitigation policy, as presented in the Federal Register, would still apply to marine projects. The fundamental principles guiding the FWS policy are: 1) that avoidance or compensation be recommended for the most valued resources; and 2) that the degree of mitigation requested correspond to the value and scarcity of the habitat at risk. Four Resource Categories have been identified; these are described, along with their associated mitigation planning goals, in Table 1 (see also Appendix 1). As with all

aspects of the FWS mitigation policy, these resource categories reflect the emphasis on habitat value. The mitigation planning goals distinguish between two fundamentally different types of mitigative compensation. In-kind replacement of resources involves resources that are physically and biologically similar to those being altered and that play similar roles in ecosystem function, whereas out-of-kind substitution of resources involves resources that are physically and/or biologically dissimilar in any number of characteristics (Ashe 1982). In-kind compensation is generally preferred, particularly for highly valued resources.

Because of its involvement in so many projects, FWS has a great deal of experience with mitigating terrestrial impacts. However, all agencies, both federal and local, have relatively little experience in mitigation in the marine environment, particularly the open ocean. The lack of experience is compounded by differences in the dynamics of marine populations and the relative lack of understanding of those dynamics compared to terrestrial populations. The lack of experience and pertinent information may hamper the application of mitigation in open coastal situations.

In addition, a narrow focus on habitat may not be appropriate for marine ecosystems. For many terrestrial projects, where direct loss of wildlife may be minimal and the target species are closely tied to particular habitat features, focusing on habitat may be appropriate. However, habitat loss is not the only type of loss during power plant operation. Impingement and entrainment of organisms result in direct loss of organisms with little or no

alteration to any habitats. For example, impingement of midwater fish does not alter the midwater habitat. Nonetheless, these are resource losses that should be compensated. Furthermore, many marine species are less restricted to use of local habitat than their terrestrial counterparts. Many invertebrates and fishes whose adults are closely associated with a particular benthic habitat have earlier life stages that are planktonic and subject to entrainment losses. Current FWS policy appears inadequate to address these problems.

1.1.2 Procedure in California

At the state level, the development of mitigation policies is extremely variable. Nonetheless, state agencies play a major role in the federal regulatory process, and strongly influence mitigation decisions. California is one of the few states that has established clear mitigation requirements in its coastal management plan. Thum et al. (1983) have reviewed the sections of the California Coastal Act and the California Environmental Quality Act that apply to mitigation in California.

In California, as elsewhere, the authority to require mitigation measures rests with the permitting agency. In addition to the permitting agency, a number of agencies serve in an advisory capacity, commenting on proposed mitigation plans and, in some cases, helping to develop the plans. For projects that affect organisms in the marine environment, the agencies in California that are involved are the California Department of Fish and Game

(DFG), U.S. Fish and Wildlife Service (FWS), and the National Marine Fisheries Service (NMFS).

The different agencies make independent comments on a particular plan, but do not have a formal, co-ordinated mitigation policy. However, as stated by officials from each agency (D. Lollock and R. Mall, DFG; J. Slawson, NMFS; C. Onuf, FWS) the general philosophy used to evaluate mitigation proposals follows the federal guidelines established by FWS. Thus, in-kind, on-site replacement of resources is the most preferred technique, and out-of-kind substitution of resources is generally less preferred. However, wetlands have been accorded such a high priority for preservation by both local and federal agencies that wetland restoration or enhancement is viewed as a relatively valuable, albeit out-of-kind, mitigative action.

In spite of California's commitment to mitigation, its application in the marine environment is a relatively recent development. Most local coastal projects that have required mitigation have involved harbors, bays or wetlands. Although maintaining a link with the marine environment, these habitats are very different from the open coastal habitat around SONGS. Few mitigation projects have been undertaken on the open coast of Southern California.

1.1.3 Application to SONGS

Mitigation can take two basic forms: avoiding potential resource losses of a project, and compensating for unavoidable

impacts. Because construction of SONGS is completed, there are limited opportunities for minimizing the impacts of SONGS, since these generally involve changing the physical structure of the plant. For example, a significant reduction in the predicted impacts (see below) might be achieved by altering the location of intake and discharge of cooling water and the method of discharge. The MRC considered this possibility in 1980, and decided that is was not desirable at that time (MRC 1980). Although included, structural changes will be considered briefly in this report.

Note that Southern California Edison has already implemented two mitigation measures at Units 2 and 3 that involved structural changes. A redesigned velocity cap has been employed to reduce fish entrapment, and a Fish Return System (FRS) has been employed to minimize death of fish that are unable to avoid entrapment. At present, MRC studies evaluating the effectiveness of the FRS have not been completed (but see section 2.4.1.1 for a summary of information to date).

The second set of mitigation techniques considered in this report involve compensation for impacted resources. The compensation may be either in-kind, in which similar (identical) resources are used to replace those lost, or out-of-kind, in which resources that are qualitatively different from the lost resources are substituted.

1.2 Impact Evaluation at SONGS

The San Onofre Nuclear Generating Station is located along the open coast of Southern California (Figure 1). The MRC has been studying the impact of SONGS on the marine environment since 1976. The effort was directed initially at documenting the effects of Unit 1, which was already operational. Subsequent work was done to develop predictions of the effects of Units 2 and 3 prior to their operations, and monitoring was started to document possible effects after they became operational.

The MRC's program to determine the effects of Units 2 and 3 has two parts, a monitoring program, based on a before-after control-impact (BACI) sampling regime, and an examination of mechanisms by which SONGS might impact organisms. Neither of these parts has been completed yet.

1.2.1 Predicted Impacts

The cooling system of SONGS could affect the marine ecosystem in a variety of ways. Fish, plankton and other organisms are killed when they are taken into the intakes. In addition, the discharge plume of Units 2 and 3 increases water temperature slightly, makes the water near the diffusers more turbid, moves water and organisms away from the diffusers to farther offshore, and influences local water movements; some of these changes in the physical environment may adversely change the abundance of some marine organisms near SONGS.

The MRC's studies have not been completed, so the actual effects of SONGS on the marine environment are not known at present. However, based on studies begun in 1978, the MRC reported its predictions about the expected effects of Units 2 and 3 to the Coastal Commission in 1980. These predictions are summarized in the following sections, and will be used as a guide in evaluating alternative means of mitigating the effects of SONGS. Because studies of the impacts have not yet been completed, the predicted impacts are of necessity discussed in general terms. Furthermore, it is understood that the actual impacts may be less or more extensive than the predictions.

Evaluation of the importance of biological impacts may be complicated by the characteristics of the species affected. For example, the range and abundance of a species will influence the severity of an impact of SONGS. For localize, rare, or exceptionally valuable species, an impact from SONGS may have critical consequences for the population structure, and perhaps even local persistence, of the species. In contrast, even if the operation of SONGS resulted in increased local mortality of widespread or abundant organisms, the overall effect on the entire population may be minimal. Because of the difficulties in predicting and measuring impacts for such species, and the possibility of unexpected impacts, additional mitigation techniques may have to be considered once actual impacts are determined. Of course, it is also possible that some predicted impacts will not occur; if this happens, some techniques (particularly for in-kind compensation or

loss prevention techniques) described in this report will not be appropriate.

1.2.1.1 Kelp

The discharged water from Units 2 and 3 may frequently replace the ambient water over the outer half of the San Onofre Kelp (SOK) bed with more turbid water from nearer shore (see Fig. 1). The increase in the turbidity of the water might interfere with the recruitment and growth of early life-stages of the giant kelp Macrocystis. It is not yet known whether such occurrences will completely suppress recruitment in SOK. Recent evidence suggests that recruitment of young sporophytes and survivorship of young and adult sporophytes may be adversely affected by SONGS (Dixon et al. 1985).

1.2.1.2 Fish

Impacts to fish are predicted to occur along three avenues: (1) impingement of juvenile and adult fishes, (2) entrainment of larval (i.e. planktonic) fish, and (3) degradation of important fish habitats.

Impingement, which occurs when fish are driven against the traveling screens and killed, is likely to exert the greatest effect on midwater fish species. The Fish Return System (FRS) has been designed to minimize the loss of fish through impingement by diverting some of the entrapped fish away from the traveling screens. The effectiveness of the FRS has been partially

evaluated, and is discussed in more detail in section 2.4.1.1. It is clear that a large proportion of the fish that enter the intakes of Units 2 and 3 are diverted by the FRS. However, the FRS is not completely effective in diverting fish, and the survivability of diverted fish has not yet been determined. Thus, the magnitude of fish losses has not been estimated yet, but there will be some loss.

The killing of fish larvae by entrainment occurs primarily by larvae being drawn into the intakes, although some mortality may also occur by being entrained in the discharged water and carried offshore. Entrainment could potentially affect any species with a planktonic stage in its early life history. The MRC predicted that entrainment could lead to a small but appreciable loss in the annual production of sport and commercial fish. The loss of larval stages is expected to have a greater impact than impingement of adult stages.

The habitat expected to be impacted involves the kelp bed at San Onofre. See Appendix 4 for a partial list of the species at risk at the San Onofre Kelp bed. A number of fish species are closely associated with kelp and may be particularly susceptible to the loss of kelp; many other species may also respond to the loss of habitat.

1.2.1.3 Benthic Invertebrates

It is also likely that the operation of SONGS will affect some benthic subtidal invertebrates. Any effect could proceed by two

mechanisms. First, species with a planktonic life history stage could be affected by entrainment, either through the intake or through the discharge plume. Second, species could be affected by alteration of habitat, particularly the kelp bed. For example, an increase in turbidity or sedimentation at SOK might lead to a change in the benthic invertebrates occurring there. A partial list of species that occur at SOK is given in Appendix 4.

1.2.1.4 Plankton

There is no doubt that zooplankton are killed as a result of the operation of SONGS. However, in spite of the huge number of plankters that are likely to be killed by SONGS, it seems probable that SONGS will have little overall effect on populations of plankton species because of their generation times.

1.2.2 Other possible impacts

The impacts discussed above are generally expected to occur as a result of the movement of water through the cooling system at SONGS. Some of the anticipated losses, such as entrainment and impingement, are the direct result of water movement, while others, such as recruitment or survival of kelp, may be influenced by water turbidity or other indirect effects. These effects caused by SONGS-induced changes in the physical/chemical environment have been the primary focus of the MRC's studies at SONGS.

There are other avenues by which SONGS could have an effect on the marine biota. It is possible that substances released from the

plant, including metals and biocides, could have adverse effects on organisms in the vicinity of SONGS. A recent report by Perry and Fay (1986) suggested the possibility that metals from SONGS could affect local marine organisms.

Particular concern has been expressed that possible effects on the sand crab Emerita analoga might indicate an adverse effect of SONGS on a wide range of organisms. Earlier work by Wenner (1982) suggested that SONGS affected the local sand crab population. The concentrations of metals in sediments and sand crabs have been determined for a number of different locations. Analyses to date indicate that metals in the sediments are as low or lower at SONGS as elsewhere (Bence 1985), but that metal concentrations in the tissues of sand crabs may be higher in the vicinity of SONGS (Parker 1985; J. Bence, personal communication). Since no impact due to metals has been determined at this time, no particular mitigation technique has been suggested for this possible effect in the present report.

1.3 Summary

The preceding outline of the predicted effects of SONGS indicates that operation of SONGS may affect plankton, benthic invertebrates, fish and kelp. Because of the commercial and ecological importance of fish and kelp, the MRC in the past has emphasized the mitigation of impacts to these resources.

It is important to identify and evaluate techniques for mitigating effects of SONGS at an early date, to allow for a full

consideration of the options and a resolution of any problems that might arise. Because operational monitoring of SONGS has not been completed, it is not possible at this time to specify the actual impacts of SONGS. Nonetheless, the probable types of effects have been identified, even if they have not been quantified. The mitigation alternatives presented in this report have been based on these possible effects.

A preliminary indication of the type of mitigative action that might be required can be obtained by placing the resources that might be impacted by SONGS into the Resource Categories established by FWS (see Table 1). The FWS has identified the types of mitigative actions that would be appropriate for the different categories of resources.

Kelp bed habitats are valued because of their ecological complexity and productivity, both among the highest of all natural habitats. Because kelp habitats are relatively scarce, especially between Dana Point and San Diego, they are classified as Resource Category 2 by FWS (J. Fancher, personal communication), and the mitigation goal is to have no net loss of in-kind habitat value.

Most of the other resources that are predicted to be affected by SONGS do not fit into the FWS's Resource Categories. This is because, with the exception of the kelp bed and its associated species, most marine species are not closely tied to a particular habitat. Because of its focus on habitats, the traditional approaches to mitigation may not work well with the types of impacts that may occur at SONGS.

Nonetheless, the general mitigation philosophy, where in-kind on-site mitigation is the most preferred and out-of-kind mitigation would only be acceptable for a very valuable substitute resource, is likely to be applied at SONGS. This philosophy is expressed in the following statement by Onuf (1985; see Appendix 3): "On the assumption that kelp beds are at least as valuable as any other habitat in open coastal areas, in-kind mitigation (creation of new kelp beds, enhancement of existing kelp beds) is likely to be most widely acceptable (if feasible). The only out-of-kind mitigations that might be acceptable are creation or enhancement of coastal wetlands (in the broad sense of shallow, protected, open water surrounded by marsh) or a hatchery program for the species of greatest local concern." Of course, the MRC is not restricted to considering only those alternatives that are likely to be acceptable to FWS and other agencies. In the next chapter, a wide range of techniques for mitigating effects of SONGS, including those suggested by Onuf, are evaluated.

CHAPTER 2

MITIGATION TECHNIQUES

This chapter discusses a wide variety of different techniques that could be considered for mitigating the effects of SONGS. The techniques included can be classified into three general categories: in-kind replacement of resources, out-of-kind substitution of resources, and preventing the loss of resources.

There are no guidelines available for conceiving or screening different mitigation alternatives (Onuf 1985, Rappoport 1979). The FWS Mitigation Policy suggests that the Habitat Evaluation Procedures (HEP; see Appendix 2) or Instream Flow Incremental Methodology be used for evaluating project impacts and as a basis for formulating recommendations for mitigation, although no suggestions are made regarding how the mitigation recommendations are to be formulated. The Mitigation Policy does suggest, though, that "where specific impact evaluation methods or mitigation technologies are not available, Service employees shall continue to apply their best professional judgment to develop mitigation recommendations" (USFWS 1981, p. 7659; see Appendix 1). The mitigation alternatives in this chapter have been developed by referring to established mitigation techniques and consulting with environmental professionals.

2.1 Resource Replacement: In-Kind Mitigation

In-kind replacement has been accomplished when impacted resources have been replaced with exactly the same quantity and type of resources. In-kind replacement is less complex to evaluate than out-of-kind substitution of resources because no objective measure of "resource value" need be applied; the same resource is compared before and after impact. Nonetheless, there are a number of difficulties to overcome. It is difficult to quantify the amount of resource involved, both before the impact and after the mitigation. It is also difficult to ensure that exactly the same resources are replaced. This problem becomes less important if mitigation is viewed within the context of the ecosystem. The ecosystem concept emphasizes the relationships and interactions between biotic and abiotic elements of a system, rather than the abundance of a single species (Ashe 1982). Similarly, habitat-based evaluation does not require that every species be present in its exact pre-impact abundance.

2.1.1 Kelp

Kelp is recognized as a valuable natural resource in Southern California. In addition to the numerous commercial uses for which it is harvested, it is a valuable component of many natural communities. It adds vertical structure to a habitat, is an important primary producer, and is food for a large number of

invertebrates as well as a few species of fish. Kelp beds have been perceived to be one of the most valuable marine habitats in Southern California, so it is not surprising that resource managers in Southern California are concerned with in-kind replacement of lost kelp bed resources. Kelp habitat is particularly rare along the coast near San Onofre.

2.1.1.1 Restoration of Existing Kelp Beds

A number of kelp (Macrocystis pyrifera) beds in Southern California have been subjected to various techniques for restoration. In the mid-forties, kelp beds adjacent to some large metropolitan areas in Southern California began to deteriorate. During this period, the discharge of domestic and industrial wastes increased near San Diego and Los Angeles, and sea urchins became more abundant (Wilson and McPeak 1983). Areas such as Palos Verdes and Point Loma historically supported large kelp beds, but became devoid of kelp in the 1950's and 1960's. Kelp restoration operations began at Point Loma in 1963 and at Palos Verdes in 1967. The restoration projects were undertaken by Wheeler North of California Institute of Technology, the California Department of Fish and Game, and others. Following the restoration projects, kelp beds re-appeared in these areas. It is important to note, however, that the water quality in these areas improved dramatically at the same time as the restoration projects (Wilson and McPeak 1983, R. Fay, personal communication), and this undoubtedly made possible the successful re-establishment of kelp.

Several different techniques can be used to restore kelp beds; these techniques are discussed in more detail in Appendix 5. In locations where the loss of kelp has been attributed to the destructive grazing of sea urchins, the first step has been to lower urchin densities. Many different methods of killing urchins have been tried; these methods are quite well-established, and reasonable success can be expected from their implementation. Kelp is then returned to the site by several methods. All methods used during the successful restoration of kelp beds have involved the transplantation of existing kelp plants, usually adult sporophytes, from healthy beds. Other techniques that could be considered, but have not yet been tested in a large-scale restoration, include outplants of gametophyte or very small sporophyte plants (see Appendix 5).

Although the restoration of kelp to areas that historically have supported kelp, but are presently devoid of kelp, is an attractive venture, it probably would not constitute an appropriate mitigation action. Kelp beds in Southern California vary considerably (Neushul Mariculture Inc. 1981, Dayton et al. 1984). Beds may disappear for a number of years, only to return naturally to their previous status. A previously-existing bed that would be restored for mitigation purposes might reappear naturally, without the mitigation effort. If the kelp would eventually have returned, the mitigation action would not result in a replacement of resources.

There are a few circumstances in which manipulation of an existing kelp bed could serve as in-kind mitigation. If the cause

of the disappearance of kelp could be identified as one that would persist without human intervention. In this case, long-term resource values would be enhanced by restoring the bed. Furthermore, it is possible that some manipulation of a kelp bed could lead to greater temporal stability or higher productivity, and this would also result in some resource replacement.

2.1.1.2 Creation of New Kelp Beds

There have been a number of efforts to create new kelp beds in California. Most of these have been associated with artificial reefs. Kelp has grown naturally on several artificial reefs in Southern California, including the Paradise Cove car body reef in Santa Monica Bay and Beaurecrat Reef in San Diego. However, in each case the bed persisted for a short period of time, then disappeared without ever recovering. (In the case of the Paradise Cove Reef, the car bodies eventually disintegrated, thereby removing the substrate available for kelp attachment.)

Kelp has been transplanted to several artificial reefs in an attempt to establish a kelp bed. The first transplant efforts were to reefs in Santa Monica Bay in 1959 and 1961 (Turner et al. 1969). More recently, adult and juvenile kelp plants were transplanted to the Pendleton Artificial Reef near San Onofre. In both of these cases, the kelp plants eventually disappeared. It has been suggested that the kelp suffered from heavy grazing by fish, but even plants protected from fish grazing in Santa Monica Bay died. The plants could have died because of conditions associated with an

El Nino that occurred during the transplant period, or because of stress associated with transplanting. Some recruitment to the artificial reefs has been noted, particularly at PAR (Table 2). However, none of the young plants have grown to adults sizes and generated a self-sustaining kelp bed.

In an experiment on factors affecting the growth of Macrocystis in cultivation, Neushul and Harger (1985) transplanted adult kelp plants (Macrocystis augustifolia) in different densities on an artificial substrate (a lattice-work of chains). (The use of M. augustifolia is interesting, since this is a more northern species than M. pyrifera, and its haptera morphology allows it to grow on sandy substrates that are unsuitable for M. pyrifera.) Although many of the original plants M. augustifolia have disappeared (primarily because of storms), enough plants still remain after several years to form a distinct canopy (M. Neushul, personal communication). However, it is not clear that any recruitment of kelp has occurred to the chains.

In spite of the problems generally associated with transplanting kelp to artificial reefs, there has been one case of successful establishment on a artificial substrate of a self-sustaining kelp bed through transplant efforts. A transplant operation to an artificial substrate in Los Angeles Harbor, begun in 1977, successfully generated a kelp bed (Rice 1983). More than 700 adults plants were transplanted over a period of 4 years. The plants were attached to floats, which were in turn attached to nylon line and anchor chain. In addition, very young plants attached to twine

were added. Two sites were selected for the initial transplant, with each site measuring 15 m x 61 m. Storms and fish grazing resulted in the virtual destruction of the plants at one of the sites; supplemental transplants at the other site maintained that bed, however. By 1979, natural recruitment occurred within the transplant area. This bed still exists in 1986, nine years after its creation (R. Fay, personal communication). Furthermore, since the creation of the bed, kelp has successfully recruited to a number of new locations along the harbor's breakwater.

The previous examples of attempts to establish kelp have involved Macrocystis. One attempt has been made to establish a different species of kelp, Pterygophora californica, which is a small understory canopy plant (LOSL 1983b). A large number of adult Pterygophora plants were transplanted to Pendleton Artificial Reef, and their status monitored for several months. However, like the transplants of Macrocystis that occurred concurrently, the transplant effort failed to establish a kelp bed.

The primary technique for establishing kelp in projects to-date has been transplanting adult or juvenile plants (see Appendix 5). Many of the failures may have been influenced by unpredictable and unfavorable oceanographic conditions beyond the control of the transplanters (Table 2). However, other factors, such as high fish densities, poor water conditions, unavailability of natural recruits, heavy sedimentation, etc., can be controlled by the choice of location for the transplant effort. The locations chosen so far may not represent the optimal ones for kelp growth, possibly

because of the multiple objectives of these artificial reef projects. In addition, there are many techniques for establishing kelp plants that have not been adequately explored.

One of the major questions to be resolved before constructing an artificial reef for mitigative purposes is the size that is necessary for 100% compensation. For in-kind replacement of fish resources, the relative amount of fish production on an artificial reef compared to a natural reef must be known to determine the size necessary for 100% compensation (see section 2.1.2.1). The resolution of this problem is potentially much easier for kelp. In many areas, including the region around San Onofre, the availability of suitable substrate seems to limit many kelp beds. Thus, providing suitable substrate of an area equal to the lost kelp resources may be adequate compensation.

2.1.2 Fish

Like kelp, fish are considered to be a valuable resource in Southern California. A number of the fish species that might be affected by SONGS have economic value, either because of a commercial fishery or the sport fishery. Even those species that are not the focus of a particular fishery may be ecologically important. Although resource managers would probably assign a wide range of "resource values" to different fish species, fish are generally considered to be a very valuable resource. Unlike kelp, there have been few attempts to actually apply in-kind mitigation techniques to fish; the techniques described in the next three

sections appear to hold the most promise for successful application.

2.1.2.1 Artificial Reefs

Information about artificial reefs and their use in mitigation has been reviewed in detail in a separate report (Ambrose 1985). This section summarizes the conclusions of the artificial reef report.

One of the most controversial aspects of artificial reefs revolves around the question of whether they actually increase the production of fish, or simply attract fish. This question is important because if an artificial reef is to be used to compensate for or offset a loss of resources, attraction alone may not be acceptable. The simple redistribution of biomass that occurs when fish are attracted to an artificial reef would not compensate for the loss of resources, since no new resources would be provided. For this reason, determining the extent to which artificial reefs contribute to fish production is a critical step towards evaluating the feasibility of utilizing artificial reefs contribute to fish production.

Fish almost inevitably gather around artificial reefs. In addition, a number of aspects of fish production have been shown to be enhanced on artificial reefs, although in most cases the data are not definitive. Some fish species feed predominantly on organisms similar to those found on artificial reefs. Observations of recruitment to temperate artificial reefs suggest that

artificial reefs may enhance the recruitment of some fish species. There have also been suggestions (but no data) that the refuges provided by artificial reefs enhance the survival of some species. In contrast, some studies indicate that artificial reefs may actually reduce survival by focusing fishing pressure on a reef. Unfortunately, most of the studies of fish on artificial reefs have not been systematic or quantitative. Existing information suggests that artificial reefs increased the production of at least some fish species. However, no study of artificial reefs in the marine environment has yet demonstrated that total fish production has been increased as a result of reef construction. Increased fish production cannot simply be assumed, particularly in light of evidence suggesting that mortality due to fishing may be increased.

In spite of the fact that artificial reefs have not been shown to increase the overall production of fish, they remain one of the most promising mitigation alternatives. A number of questions about their function need to be answered before they can intelligently be implemented, however. The primary unknowns include the influence of different design features or configurations, and the similarity (in terms of the abundances and productivity of organisms) between artificial and natural reefs.

There are a wide range of design possibilities for artificial reefs; however, reef construction in California has historically focused on a fairly limited set of configurations, and it seems likely that any reef intended as a mitigation measure would not depart greatly from this set. The typical California reef is

constructed from blocks of quarry rock. The quarry rock is placed in large piles; many reefs, particularly those built most recently, have consisted on a number of piles (or modules) separated by a hundred or more meters of sand. Nearly all artificial reefs in Southern California have been surrounded by a large expanse of sand.

Even utilizing the general type of artificial reef constructed in California, there are a number of variations in configuration that could significantly alter the mitigation potential of the reef. It would be advisable to understand how these factors influence the function of an artificial reef, preferably before beginning the planning stages and certainly before beginning construction.

The function of an artificial reef must be compared to that of natural reefs in order to evaluate the relative benefit to be derived from the artificial reef. This information is critical for determining the size of the artificial reef to be constructed. Only by knowing how much better (or worse) fish production is on an artificial reef will we be able to determine how large a reef should be to achieve 100% compensation for loss of production on a natural reef. It is therefore important to quantify the extent to which fish production can be increased, rather than simply whether it is increased. The productive potential of an artificial reef could then be used in a manner similar to the way FWS uses habitat value: information on the relative productivity of artificial reefs could be used to determine how extensive a reef must be in order to

provide 100% compensation. At present, the information on fish production is not sufficient to provide the required estimates of benefits.

2.1.2.2 Fish Hatchery

A hatchery could serve to mitigate the loss of fish resources by providing juvenile fish for release in the wild. The potential use of fish hatcheries in mitigation is controversial. Hatcheries seem to be a promising method for restoring the populations of some species, particularly anadromous fishes. However, the efficacy of their use for marine species has not been demonstrated.

Salmon hatcheries represent a model for attempts to restore a fishery. Although not all problems related to the salmon fishery can be solved by building hatcheries, in cases where the number of smolts entering the sea limits the number of adults that return to freshwater, a hatchery (as well as other techniques) can effectively enhance the fishery (Ellis and McNeil 1979, Peterman 1980). All major salmon producing nations are currently enhancing salmon stocks (Healey 1980); in California, the Department of Fish and Game operates six salmon and steelhead hatcheries, with the Mad River hatchery designated for the maintenance and enhancement of salmonid runs in California (Hassler 1984). Salmon represent an ideal situation for a hatchery program. Salmon are one of the most extensively studied fish, so critical factors in different life stages have been identified (see McNeil and Himsworth 1980). Furthermore, the return of adults to the stream in which they were

born makes them ideal for both enhancement efforts and studying the effects of enhancement efforts.

In contrast to the situation with salmon hatcheries, the effectiveness of hatcheries for marine fish has not been firmly established. In California, the feasibility of marine fish hatcheries is just beginning to be evaluated. Two species have been targeted by the California legislature and the Department of Fish and Game for research with regards to establishing a hatchery program: the white seabass, Cynoscian nobilis, and the California halibut, Paralichthys californicus. These programs are still in their early stages, so there are no data on their effectiveness.

The rearing program for the California halibut has been undertaken jointly by DFG and Southern California Edison at Edison's laboratory in Redondo Beach. Halibut have been successfully reared from egg to post-feeding juveniles (approximately 2 cm long). The techniques for raising larvae have been developed; at present, one of the difficulties is inducing the adult halibut to spawn, in order to insure a constant supply of eggs (K. Herbinson, personal communication).

The program for rearing white sea bass is located at Hubbs Research Center in San Diego. The program has been successful at getting two groups of white sea bass to spawn at any desired time, regardless of the normal spawning period. Techniques for collecting and hatching eggs have been worked out, and the program is now experimenting with the effects of different rearing densities and food types (D. Kent, personal communication). A very few animals

have survived for up to two years; there are presently no estimates of survivability, but these will soon be generated from a spawn of 2000 eggs.

Even if the potential for rearing young marine fish is realized, it is not clear that a hatchery program will satisfactorily compensate for impacts to fish. For example, the bottleneck for California halibut could be the nursery habitat for young-of-year (Allen et al. 1985); if so, no matter how many young halibut are released, only a certain number will survive, and survival may depend heavily on where they are released. The situation with the white sea bass may be even more problematic. Little is known about their natural history, although the early life history of white sea bass appears to be quite complicated (K. Herbinson, personal communication), and the potential bottlenecks have not yet been identified. In contrast, the bottlenecks have been identified in the salmon fishery, and it is clear that a hatchery could enhance the fishery (Ellis and McNeil 1979, Healey 1980, Peterman 1980). It is clear that more information about the life history of marine fish species must be known in order to determine whether a hatchery will be successful for mitigation.

Finally, it is not obvious which fish species should be chosen for hatchery rearing. SONGS could potentially impact a multitude of species, yet not all species can be reared in a hatchery and released. Selection probably should be based on species that are ecologically or economically important and can be reared in a cost-effective manner; furthermore, there should be evidence that

populations of the reared species would actually benefit from the hatchery program.

2.1.2.3 Restoration of Nursery Habitat

Some fish species at risk at SONGS may be closely associated with a particular habitat during their early life stages. If this habitat supports a critical life stage, and the habitat has been degraded by anthropogenic activities, then restoration of the habitat could result in increased population sizes for the target species. This approach to habitat restoration is close to the approach taken for many terrestrial mitigation projects. Restoration of nursery habitat could also be used as an out-of-kind mitigation technique for species that are not at risk at SONGS.

For many fish species, coastal wetlands are purported to be essential nurseries. Zedler (1982) has reviewed information on the use of California coastal wetlands by fish. Species using wetlands in Southern California for spawning or nursery grounds are listed in Table 3. The California halibut and diamond turbot (Hypsopsetta guttulata) are the commercial species most often cited as using wetland channels for nursery grounds, but many other taxa use a variety of wetland habitats. Radovich (1982) suggests that several fish species, such as the California yellowfish, need wetlands to survive, and that others, such as white sea bass and California halibut, benefit from wetlands. Norby (cited in Zedler 1982) suggests that estuaries are used by transient species that come in

to spawn; in addition, larvae may encounter fewer predators in estuaries.

Because the life histories of all the species at risk at SONGS are imperfectly known, it is not possible to provide a definitive list of species that would be candidates for restoration of their nursery habitat. However, recent work by Allen et al. (1984, 1985) for the MRC indicates that California halibut might benefit from such restoration. Young-of-year halibut apparently do not occur in exposed beach areas, but rather are concentrated in embayments. Allen et al. (1985) estimate that 90% of the suitable harbors in California have been altered. Thus, destruction of nursery areas may have contributed to the decline in halibut populations. It is possible that restoration of some nursery areas could result in a larger halibut population size.

Kelp bass (Paralabrax clathratus) populations might also benefit from habitat restoration. Recent work by Carr (1985) has indicated that very young kelp bass are closely associated with Macrocystis plants. This early life stage of kelp bass could represent a bottleneck for the population. If so, creation of new kelp habitats or modification of existing beds could enhance the kelp bass population.

There are two classes of problems associated with restoring nursery habitats: inadequate information, and logistical difficulties. For many species, including the California halibut, the critical habitat parameters have not been identified, so it is not clear which features of the habitat should be altered to make the

habitat more suitable for halibut. Logistically, one problem with habitat restoration projects is that they can be costly. Perhaps more importantly, the anthropogenic activities that originally made the habitat unsuitable may still be occurring, and may have a higher priority that halibut. For example, port activities in Los Angeles, Long Beach and San Diego may be incompatible with suitable halibut habitats, but probably cannot (and should not) be curtailed in order to achieve suitable habitats. Thus, the number of sites available for restoration may be severely limited. Furthermore, there have been few attempts to restore likely nursery areas such as embayments (see section 2.2.1), so the necessary techniques have not been developed.

Because of these problems, it seems likely that restoration of nursery habitats will not be a widely applicable technique for in-kind replacement of fish resources. However, under the correct circumstances it could be valuable. Further information on the early life stages of species at risk at SONGS would help identify cases for which nursery restoration might be suitable.

2.1.3 Benthic Invertebrates

Few of the benthic invertebrates that might be affected by SONGS are commercially valuable. However, invertebrates in general play an important role in ecosystem function, and thus it is worth considering ways in which this resource could be replaced.

2.1.3.1 Artificial Reefs

One possible in-kind compensation method for benthic invertebrates would be the construction of an artificial reef.

A great deal of research has been devoted to following the succession of invertebrates on artificial reefs (e.g. in California, see Turner et al. 1969 and LOSL 1983a, 1983b, 1983c). These data clearly indicate that the invertebrate fauna of an artificial reef changes over time, so that for many years the fauna of an artificial reef may differ from that of a natural reef. Nonetheless, many of the species occurring on natural reefs also occur on artificial reefs, and there is no reason to expect that the community occurring on an artificial reef would not eventually be identical to that expected on a similarly-configured natural reef. However, the time-table for convergence of natural reefs is not known.

2.1.3.2 Invertebrate Hatchery

The mariculture of invertebrates has a long and successful history. In many countries, such as Japan and other Asian countries, mariculture is an important industry. Techniques for invertebrate rearing are constantly improving, making invertebrate hatcheries more efficient (see Morse 1984, Morse et al. 1984). It has also been demonstrated that warm-water effluent from power plants can be used to advantage for rearing invertebrates (Leighton et al. 1981). Along the Pacific Coast of North America, attempts

have been made to culture oysters, abalones, clams, mussels and scallops; only scallops are not currently cultured for the commercial market (Chew 1984). Unlike fish hatcheries, however, invertebrate cultures generally have not been used to enhance fisheries. One exception to this general rule is the commercial rearing of abalone (Ebert and Houk 1984), where a number of outplants have been made to try to restore the abalone fishery in California.

The experimental abalone enhancement program began in the late 1970's (Tegner 1984a). Four approaches have been used to enhance abalone stocks: (1) seeding hatchery-reared juveniles, (2) habitat modification to provide nursery areas, (3) fishing closures to allow natural recovery, and (4) transplantation of adults as brood-stock. Seeding has occurred at a number of locations in Southern California, including San Miguel Island, Palos Verdes Peninsula, Santa Cruz Island, Pendleton Artificial Reef, and Santa Barbara (Tegner 1984a, Schmitt and Connell 1984). In spite of the tremendous numbers of abalone outplanted, there is no evidence to suggest that any outplants have been successful (Tegner 1984b), and one definitive study demonstrated that two outplants at Santa Barbara failed (Schmitt and Connell 1984).

Besides using commercially-reared abalone to enhance a fishery, mariculture of a number of invertebrate species could be considered for mitigation. Depending on the species, this technique could be considered either in-kind or out-of-kind. Species that might be considered are oysters, shrimp, and lobsters.

Chew (1984) discusses current hatchery efforts for oysters, clams, mussels and scallops. Recent work by Leighton and Phleger (1984) suggests that the rock scallop (Hinnites giganteus) may also be a good candidate for culturing.

2.1.3.3 Habitat restoration

In general, there appear to be few techniques for manipulating habitats specifically for the purpose of mitigating the loss of invertebrate resources. However, surfgrass appears to serve as a nursery area for spiny lobsters (Panulirus interruptus) (Engle 1979), so that restoration or enhancement of surfgrass habitat might be considered as a means of enhancing lobster populations. The possibility of altering the habitat to favor abalone recruitment or survival has also been raised (Tegner 1984a). The Japanese make extensive use of habitat modifications, mostly in conjunction with artificial reefs, to increase the yield of their invertebrate fisheries or mariculture projects (Mottet 1985, Momma et al. 1980). The Japanese have focused on abalone and urchins; some of the techniques used by the Japanese might be applicable to Southern California species.

2.1.4 Plankton

It seems likely that there is no way to provide in-kind replacement of plankton.

2.2 Resource Substitution: Out-of-Kind Mitigation

The goal of out-of-kind substitution of resources is the same as for in-kind replacement, that is, the value of the resources after mitigation should be the same as before the project existed. However, planning for and documenting the achievement of this goal is far more difficult, since the resources involved before and after the project are different. To insure that 100% compensation is achieved, some objective measure of "resource value" must be applied.

As with in-kind replacement of resources, it is difficult to determine the amount of resource involved, both before the impact and after the mitigation.

One of the largest obstacles to objective application of out-of-kind mitigation is the difficulty of putting a value on dissimilar resources. There have been many different approaches to this problem. The traditional approach is to value the resource according to its market value. Unfortunately, wildlife resources tend to be undervalued by this approach. Gosselink et al. (1974) have attempted to value resources according to their ecosystem function, as measured by energy flow. Although this general approach is admirable, the specific methodology employed by Gosselink et al. has been severely criticized (Shabman and Batie 1978). There presently is no consensus regarding the technique to be used for valuing resources. The FWS has developed their Habitat Evaluation Procedures in part to avoid problems of subjective

evaluation of dissimilar habitat resources. At present, however, there is no generally accepted technique for valuing wildlife resources. Onuf (1985) states that "the determination of the relative values of grossly different kinds of habitat is a matter of interpreting policy, not the application of a method of habitat assessment which assumes that the same resources are at issue." In practice, the appropriate level of effort in out-of-kind compensation is decided subjectively by resource managers.

2.2.1 Habitat Restoration and Enhancement

Habitat restoration is one of the most frequently used techniques for mitigation, both for in-kind replacement and out-of-kind substitution of resources. Many restoration projects have been undertaken in terrestrial, freshwater and marine or estuarine habitats.

The prevailing emphasis on habitat restoration is undoubtedly due in part to the habitat-based mindset of resource managers, as reflected (and to some degree directed) by the FWS mitigation policy (see Appendix 1). In other words, if impacts to be mitigated are measured in terms of habitat value, then mitigation techniques will naturally focus on habitats. I have argued earlier that the emphasis on habitat associations may not be as appropriate for some marine species, so that in-kind replacement of resources may not be possible by focusing solely on habitats. Nonetheless, restoring degraded habitats remains a valuable mitigation alterna-

tive. For impacts in the marine environment, habitat restoration is particularly attractive as an out-of-kind technique.

The importance of protecting and restoring wetlands has become widely recognized. The high value given to wetlands is reflected in the California Coastal Commission's Statewide Interpretive Guidelines for Wetlands (1981). The restoration and enhancement of coastal wetlands in California has become a significant activity in the past decade, with projects ranging in size from less than an acre to over 200 acres, and designs ranging from small-scale vegetation planting to earthmoving and tidal restoration (Josselyn and Buchholz 1982).

Between the Mexican border and Point Conception there are about 30 wetlands (Figure 2; Zedler 1982); development has destroyed 70-80% of these areas (California Coastal Zone Conservation Commission 1975). To counter this trend, a number of wetland restoration projects have been implemented along the coast of California in recent years. Josselyn and Buchholz (1982) report 33 coastal wetland restoration projects completed in California by 1982; most of these projects were in San Francisco Bay. Six of the 16 restoration projects involving major substrate alterations served mitigation objectives; two of these, Big Canyon in Newport Beach and San Diego Bay Wildlife Reserve in Chula Vista, occurred in Southern California. Gates (1982) has compiled an extensive inventory of coastal wetlands throughout California that have a potential for restoration. Gates reports 20 current restoration

projects in Southern California, many in the planning or review stages (Table 4).

There are many techniques that can be used to restore or enhance a degraded wetland; these techniques have been summarized by Zedler et al. (1982), which is included in this report as Appendix 6. Williams and Harvey (1983) also discuss some of the details of designing a salt marsh restoration project. Wetland restoration projects have involved construction of dikes, channels and islands; installation of tide gates or other water control structures; regulation of water levels; introduction of vegetation; and manipulation of animals. For example, Zedler (1984) has been working on the artificial establishment of cordgrass (Spartina foliosa), particularly by transplantation and germination from seed. Cordgrass has been planted at the San Diego River marsh, Tijuana Estuary, and South San Diego Bay (Zedler 1984). The technology of wetland construction is still at an early stage, and more importantly, the successful establishment of a wetland community as a result of wetland restoration has not been documented (Race 1983, Barnhart and Boyd 1984).

Seagrass habitats are also considered to be rich, productive habitats, and restoration of seagrass habitats has received increasing attention in recent years. Seagrass has been transplanted and anchored in a number of different ways: clumps or "plugs" of turf have been moved (Goforth and Peeling 1979, Breedveld 1975); seeds have been planted (Churchill et al. 1978); and whole short-shoots have been planted without associated

sediment (Churchill et al. 1978, Fonseca et al. 1979). These methods have achieved varying degrees of success.

2.2.2 Coastal Preservation

Recently, groups concerned with maintaining the quality of the environment have acquired land to set aside as preserves. Land acquisition has also been used as mitigation for some coastal development projects (Ashe 1982). Acquiring and preserving coastal land could serve to mitigate impacts to the marine environment.

However, resource preservation per se is not consistent with the general philosophy of mitigation. With preservation alone, no resources are produced to compensate for project-related losses, so that there is a net loss of resources. This approach simply tries to protect some of the remaining wildlife resources, rather than trying to return the resources in the system back to their pre-project level.

Land acquisition could be appropriate mitigation if the acquired land would otherwise be degraded; if this were the case, than preserving the land would not necessarily result in a long-term loss of resources. Given the recent history of the development of coastal lands in California, land acquisition might be a viable mitigation technique for SONGS. For example, wetland habitat is in danger of elimination in California in spite of its perceived value; since much of the wetland habitat is in private ownership, Zedler (1982) argues that development in and around wetlands will continue unless wetlands or easements are purchased

for public management. In this situation, where the resource would eventually be lost to development unless the land is acquired and preserved, coastal preservation could serve as a valuable technique for maintaining long-term resource values. Land acquisition is an even more attractive alternative if the acquisition is accompanied by a habitat restoration effort to restore the value of the land (see section 2.2.1).

2.2.3 Information Acquisition

Mitigation can sometimes take the form of studies, if there is a recognized lack of knowledge about the resources involved. Studies could be particularly valuable where actions or recommendations by government agencies have been hampered by the lack of information.

There have been a number of cases where studies have been recommended as at least part of the mitigation requirement. Recent examples in Southern California, cited by Nancy Gilbert of the Division of Ecological Services of Fish and Wildlife, include: 1) Study of an adjacent lagoon was recommended in response to building on a mesa; the study was to provide information about the value of the lagoon that would be valuable for future management decisions. 2) Study of the impact of isolation on the ecological functioning and integrity of vernal pools was recommended as part of an overall mitigation package that included preserving existing vernal pools. 3) Study of the effects of shading on eelgrass was recommended as

part of a recent permit for a development that would impact eelgrass beds.

A significant problem with using research as a mitigation technique is that research does not directly change resource values. Thus, after the research is completed, there still could be a net loss of habitat or other resource values; for this reason, many resource managers do not consider information acquisition to be valid mitigation (J. Fancher, personal communication). In the long-term, however, research could be very beneficial. Research into mitigation problems and applied solutions could ultimately result is increased resource values through the application of novel techniques or information. This technique would be most useful where traditional mitigation techniques are inappropriate, or there exists no clear consensus on the procedure to follow for a particular resource, such as mid-water fishes or plankton. It could be implemented as a separate technique, or it could be integrated as a condition of a permit, in conjunction with implementing another technique.

2.2.4 Monetary Payment

It is possible for reductions in resource value to be compensated for by calculating the monetary value of the resources, and paying an appropriate amount to the agency charged with protection of the resources. Two different directions have been taken with this approach. In the first, the payment involves "nondesignated fees", where the money is directed into a general wildlife fund.

In the second, the payment involves "designated fees", where the money is directed specifically for the mitigation of specific project-related impacts. Ashe (1982) does not consider nondesignated fees to be a viable mitigation option, since they do no address the impacts at issue. However, designated fees could be appropriate under the proper administrative framework.

The purpose of payments in lieu of mitigation is to generate funds that will be sufficient to finance an effective program of mitigation. Determining the appropriate dollar value of the resource is a major problem. The dollar value chosen has traditionally been the result of an arbitrary decision process and rarely reflected the full value of the resources lost (Ashe 1982). Ashe suggests that monetary payments will only be a viable alternative when they represent the true replacement cost of the altered resources (i.e. payment sufficient to provide for replacement resources).

An example of the application of designated fees in mitigation is the Vernal Pools Preservation Fund in San Diego County (Gilbert, personal communication). The purpose of the Fund is to purchase and preserve existing vernal pools. Developers who will impact vernal pools make payments into the Fund; the money is banked until sufficient funds exist to begin managing the pools. Although the fees are designated, there are a number of problems with this approach, including the fact that preservation is the goal, so there will be a net loss in habitat value. The Vernal Pools Preservation Fund acts like a mitigation bank in reverse (see

section 2.3); it might be termed a "mitigation loan", since resources are actually "lent" to the developers until the Fund becomes active.

2.2.5 Water Quality Improvement

One mitigation technique that has been utilized in terrestrial environments is to have the company responsible for a project to reduce the impacts to the environment that are produced by a separate, unrelated project. The California Air Resources Board has required that new sources of air pollution, if permitted, should cause a net benefit in the air quality of the region. The policy is based on the theory that air quality impacts in one area can be mitigated by air quality improvements at another site within the "airshed" (Ashe 1982). For example, Standard Oil had agreed to reduce Southern California Edison's emissions at a power plant as mitigation for one of Standard Oil's proposed refineries (Ashe 1982). Similarly, oil drilling and processing developments in the Santa Barbara may mitigate their impacts on air quality by improving emissions of other operations off-site (B. Durous, personal communication). In both cases, the underlying idea is that the project-related impacts are mitigated because the overall air quality has not been degraded.

A similar approach could be used for water quality in the Southern California Bight. As mitigation for adverse effects of water quality as a result of discharged water from SONGS, SCE might improve the water quality at another site within the Bight. Any

number of different impacts to water quality would be eligible for improvement. For example, a sewage treatment plant might be upgraded, or an industrial discharge improved. The mitigation effort could involve a general improvement in water quality, or it might be tied to a particular aspect, such as the heavy metals.

2.3 Mitigation Banking

Mitigation banking is a procedure that can be used for either in-kind replacement or out-of-kind substitution of resources. FWS refers to mitigation banking as "predevelopment compensation actions", where habitat values are banked for the express purpose of compensating for unavoidable losses that might occur in the future (USFWS 1981). A mitigation bank acts much like a monetary bank: "deposits" are made to establish "credits", and these credits are debited as circumstances require. The deposits are established by undertaking a particular project that restores a habitat or is otherwise appropriate for mitigation before the development activity takes place; the value of the project is determined by the government agencies involved. The key to the mitigation banking concept, however, is that the mitigation project is not necessarily tied to any particular development project. Thus, if an organization plans a number of projects that will require mitigation, it can undertake one large mitigation project that will eventually cover a number of different development projects, rather than mitigating each project separately, on a piecemeal basis. A

mitigation bank can also be established for many different developers.

There are a number of advantages to mitigation banking. Pooling the mitigation requirements for a number of different development projects allows comprehensive planning for a larger mitigation effort than would otherwise be possible. A mitigation bank would facilitate mitigation in conjunction with small-scale developments, which generally lack the expertise and infrastructure necessary to undertake independent mitigation efforts (Ashe 1982). Because the mitigation has already taken place, the actual cost of providing resources has been established; thus, mitigation banking is an ideal framework for utilizing monetary payments (see section 2.2.4).

Although the FWS Mitigation Policy encourages mitigation banking, its actual application is controversial. There are a number of practical problems to be solved, including the logistical problems of cataloging and acquiring potential mitigation sites. Mitigation banking has not been used extensively in California. Because this report is evaluating mitigation approaches that can be used specifically at SONGS, mitigation banking <u>per se</u> is not applicable, since there is only one development project involved. However, if an appropriate mitigation bank did exist, the impacts from SONGS could be applied to it.

2.4 Loss Prevention

Loss prevention techniques avoid the unnecessary loss of resources. In general, loss prevention is the most desirable form of mitigation; it insures maximal protection of the environment, and minimizes the need for compensation. Ideally, techniques to prevent losses have been considered and implemented during project planning and construction. However, planning during project development is not possible at this time for SONGS, so that any loss-avoidance measures would have to be implemented after construction. The Coastal Commission has recognized that requiring design changes such as cooling towers, extending the diffusers hundreds of feet or converting the discharges to single point discharges could cost hundreds of millions of dollars (Fischer 1979).

In this section, I have identified some possible techniques for preventing resource losses at SONGS. For most of these techniques, procedures for implementation, including the effectiveness of each technique, have not been worked out in detail, since these would involved engineering aspects that are beyond the scope of this report. Furthermore, changes in the structure of the cooling system at SONGS could result in a whole new set of effects on species. In general, the consequences of such changes are not known; the effects could be either beneficial or adverse for any particular species.

The locations of the intake and discharge systems at SONGS, which are discussed in the following sections, are presented in Figure 3.

2.4.1 Intake

In the process of acquiring water for cooling, a number of different organisms are taken into the plant. Small organisms simply pass through the plant; losses to these organisms result from physical damage incurred during transit and predation by the fouling organisms that occur in the cooling system. Larger organisms, primarily fish, may be impinged on the travelling screens.

2.4.1.1 Fish Return System

The Fish Return System (FRS) was designed to minimize losses due to the impingement of fish on the travelling screens. Entrapped fish are diverted into quiet areas of screenwell forebays before they reach the screens (Figure 4). The diverted fish are periodically collected by lift-bucket from these quiet areas and moved that move to a conduit through which they can return to the ocean.

A number of studies have evaluated the effectiveness of the FRS. Under full-flow conditions, the FRS returns an estimated 97% (by number) and 96% (by weight) of the entrapped fish back to the ocean (DeMartini 1985). The FRS is somewhat selective in which fish are diverted, both by species and size. For example, white

seaperch, plainfin midshipman and giant kelpfish were more numerous in impingement samples than in diversion samples, while topsmelt, yellowfin croaker, sargo and zebraperch were relatively more numerous in diversion samples. The FRS diverts disproportionately more large individuals of many small-bodied species that are frequently entrapped at the intakes. It appears that the young-of-year of many species, including queenfish, are particularly susceptible to impingement. In contrast, the adults of small species, as well as the larger juveniles and adults of large, robust, and strong-swimming species, are successfully diverted.

Although the diversion efficiency of the FRS is generally high, the survival of the diverted fish has not yet been tested. Survival could be low because of physical stress or predation following discharge. Preliminary analyses suggest that, in the absence of predation, survival for at least the first 96 hours after discharge may be high. A more complete study of survival after discharge is currently being completed.

2.4.1.2 Relocate Intake

Relocating the intakes to deeper water could change the effects of SONGS in two ways. First, by taking in less turbid water offshore, water turbidity near the discharges might be reduced, thus lowering impacts on the kelp bed. Second, by taking in water at a different depth, a different mix of fish species might be impinged and a different mix of plankton, both ichthyoplankton and zooplankton, might be entrained. It is

possible that impingement and entrainment from deeper intakes would result in lower impacts than from the present location; it is also possible that the impacts would be greater.

Moving the intakes to deeper water might bring up cooler, more nutrient-rich water. Increased nutrients might increase the productivity of the kelp bed. Cooler water could mean that a lower flow rate through the cooling system would be necessary. Both of these consequences would be beneficial. On the other hand, locating intakes in deeper water might require more powerful pumps, so there may be considerations of design constraints.

The MRC briefly considered the consequences of extending the intakes out to deeper water (MRC 1980). The preliminary conclusions were that (1) much of the turbidity will result from secondary entrainment by discharged water, so there would be little to gain from moving the intakes, and (2) moving the intakes might reduce fodder fish kills, but might also kill more sport and commercial fish.

2.4.1.3 Velocity Cap

The intakes at SONGS Units 2 and 3 have been redesigned to include a velocity cap in an effort to reduce the entrapment of fish. Velocity caps are designed to reduce entrapment by producing a horizontal flow field rather than a vertical flow field at the entrance to the intake tower (Figure 5). The "accelerating flow" velocity cap at SONGS was designed to provide fish with more time to sense the horizontally flowing intake current.

In the past, there has been some controversy over the effectiveness of a velocity cap because of the absence of valid field demonstrations (Thomas et al. 1980). Stupka and Sharma (1977) suggested that the velocity cap at SONGS "may actually serve to enhance the entrapment of fish." However, studies by Thomas et al. (1980) suggest that the velocity cap design does reduce the vulnerability of species to entrapment. Thomas et al. also report temporal variation in the effectiveness of the velocity cap: entrapment without the velocity cap was generally an order of magnitude greater than with the velocity cap during daylight hours, whereas without-cap entrapment was only 2 to 3 times greater at night. Entrapment with the velocity cap was lower for most species, although entrapment of small white surfperch was similar during with-cap and without-cap operations. Thomas et al. (1980) conclude that their study "demonstrated that in spite of the large amount of natural variability in fish vulnerability to entrapment, the addition of velocity caps to the intake tower design represents an effective treatment for minimizing fish losses."

2.4.2 Discharge

The discharge of cooling water from SONGS Units 2 and 3 could have an effect on the surrounding biota in two ways. First, the discharged water could replace the ambient water, thereby changing the physical or chemical characteristics of the water. For example, the discharged water could be more turbid than the ambient water, thus reducing light penetration or increasing sedimentation.

Second, the movement of the discharged water could carry with it marine organisms. This effect could be manifested through increased mortality of organisms due to physical stress, or through displacement from their natural habitat.

2.4.2.1 Alter Existing Discharge System

The simplest way to reduce the effects of the multi-port diffusers might be to alter the existing system. Altering the port angles might change some of the plume characteristics; at present, the diffuser jets are pointed offshore (20^{o} angle upwards and 7^{o} angle outwards) from the line of the diffuser, in order to generate an offshore movement of discharged and entrained water. It is possible that a different port angle would have a reduced effect on the marine biota.

2.4.2.2 Redesign Discharge

Much of the impacts of the discharge system at SONGS results from its multi-port design. Heated water from Units 2 and 3 is discharged through long diffuser tubes, with each unit having its own diffuser with 63 ports. The discharge is initially diluted about tenfold with entrained water passing the diffusers. The diffuser for Unit 2 extends from 1700 to 2450 m offshore, while that for Unit 3 extends from 980 to 1740 m (Figure 3). In contrast, the discharge system for Unit 1 consists of one large discharge port located 660 m from shore. Although the diffusers were designed to satisfy thermal requirements for the discharge,

the MRC (1980) has speculated that a single-port discharge might be less damaging to the marine biota. Although water discharged from a single port might result in higher surface water temperatures, the MRC suggested that this might be less damaging than the increased turbidity and entrainment resulting from the multi-port diffusers, although no detailed studies of the problem were conducted. The MRC decided in 1980 that there was not sufficient evidence of adverse effects at that time to recommend a change in the discharge system, including a change to a single-port discharge; however, this alteration remains a possibility.

2.4.2.3 Relocate Discharge

Units 2 and 3 presently discharge water over depths of 9.6 m to 14.9 m; furthermore, the diffusers are adjacent to the San Onofre Kelp (SOK) bed. If the diffusers were moved closer to shore, into shallower water, or farther offshore, into deeper water, the discharged water might have less impact on the marine biota. Removing the discharge from the vicinity of SOK would likely lessen, and might eliminate, any detrimental effects of SONGS on SOK. By locating the discharge in deeper water, it might be possible to utilize a different discharge design, yet still meet state thermal standards. Relocating the discharge to deeper water farther offshore would change the characteristics of the discharge plume, with possibly beneficial effects on the mortality of organisms due to entrainment with discharged water. A different

set of benthic organisms might be influenced by a deeper discharge, with unknown consequences.

2.4.3 Cooling Towers

By drastically reducing the volume of water utilized by the plant, cooling towers would reduce nearly every impact to the marine biota that is expected to result from the operation of SONGS. However, cooling towers can also have significant environmental impacts, on the terrestrial environment through deposition of salt from drift, and on water quality by the addition of biocides and corrosion-inhibiting chemicals to the cooling water (Edmonds et al. 1975, Taylor et al. 1975, Glasstone and Jordan 1980).

2.4.4 Restriction of Operations

Because most of the effects of SONGS are a direct result of the operation of the once-through cooling system, reducing the amount of time the plant operates would reduce many impacts. If curtailing plant operations at a specific, critical time results in a disproportionate reduction in impacts, then restricting plant operations during the critical period might be a worthwhile mitigation technique to consider.

Such a situation has been identified for striped bass (Morone saxatilis) in the Hudson River estuary. The Hudson River estuary provides spawning and nursery habitat for the striped bass, an anadromous fish that is highly valued in the sport and commercial

fisheries. A controversy developed around the effects of Hudson River power plants on the striped bass population. The major impact on the striped bass population came from entrainment of eggs and larvae, and the only effective way to reduce entrainment is to reduce the amount of water withdrawn by the plant. Three alternatives were identified for reducing the amount of water withdrawn: 1) build cooling towers; 2) reduce the water flow and increase the temperature of the discharged water; and 3) shut down generating units when entrainable organisms are abundant (Barnthouse et al. 1984). The utilities on the Hudson River agreed to implement flow reductions and scheduled shutdowns. Data on the temporal abundance patterns of the different life stages of the striped bass were combined with information on the life stages that accounted for most of the impact of entrainment to determine when mitigation efforts should be focused.

Reduced water flow has the potential for reducing entrapment at SONGS. Although not as effective as the velocity cap, Thomas et al. (1980) found that reduced flow reduced the vulnerability of fish to entrapment.

Temporal restriction of operation of SONGS is possible, but would be most effective if there was seasonal variation in the risk to a species. For many species at San Onofre, this is either unlikely or there is too little information to know. DeMartini (1985, Appendix K) estimates the monthly loss of many fish species between May 1983 and December 1984; although there is a great deal

of monthly variation, there do not appear to be clear seasonal trends.

At San Onofre, there is concern over the effects of the discharge plume as well as entrainment and impingement. Of particular concern is the effect of the discharge plume on the recruitment and survival of kelp in the San Onofre Kelp bed. Kelp recruitment depends on the occurrence of appropriate environmental conditions. Between 1978 and 1984, recruitment at San Onofre occurred during upwelling events that coincided with periods when irradiance levels were above the threshold required for gametogenesis (Dean et al. 1986). All recruitment events occurred during these "recruitment windows", although not all windows produced recruitment. Dean et al. (1986) have proposed that these "windows" are relatively infrequent, and that increased turbidity from the SONGS discharge may reduce the frequency or likelihood of successful kelp recruitment.

If kelp recruitment is more likely during some portion of the year, it is possible that restriction of SONGS operations, particularly by curtailing operations, could alleviate the problems of water turbidity and allow normal recruitment events to occur. Anderson and North (1967) noted that, although spores are produced throughout the year by Macrocystis in Southern California, there are peaks of production in late spring/early summer and early fall. At the San Onofre and San Mateo kelp beds, recruitment has indeed been seasonal, occurring in Summer 1978, Spring 1979, Summer-Fall 1981, Summer 1983 and Spring 1984 (Dean et al. 1986). Because the

conditions necessary for kelp recruitment may only occur 3 to 4 weeks per year, and appear to be generally seasonal, restricting the operation of SONGS during these periods might reduce the impacts on the kelp bed. However, the unpredictable timing of the recruitment windows within the general recruitment season will greatly limit the usefulness of this technique.

2.5 Summary and Discussion

A wide variety of different techniques could be used to mitigate the possible effects of SONGS (Table 5). In-kind replacement of lost resources might be accomplished by enhancing existing kelp beds, creating new kelp beds, constructing artificial reefs, constructing fish hatcheries, restoring fish nursery habitats, constructing invertebrate hatcheries, and manipulating natural habitats. Out-of-kind substitution for lost resources could be accomplished by any of the in-kind techniques; in addition, habitat restoration or enhancement (particularly for wetland habitats), preservation of coastal lands, information acquisition, monetary payment and water quality improvement could be used for out-of-kind compensation. Many of these compensation techniques, particularly the construction of artificial reefs, the restoration or enhancement of habitats, and monetary payments, could be used in a mitigation banking framework. The actual loss of resources at SONGS might be minimized by relocating the intakes, altering or relocating the discharge system, building cooling towers, or restricting the water flow rate or periods of operation of SONGS; the full

consequences of most of these possible changes have not been evaluated in detail.

Each of the techniques presented in this chapter could serve as a technique for mitigating the effects of SONGS. It is difficult to choose among these techniques because there are many factors influencing such a decision, and most of these factors are not known at this time. Thus, it is not possible to exclude most techniques from consideration. However, it is possible to suggest the techniques that seem best suited to the situation at SONGS, given our present understanding. These preferred techniques include:

1. Create a kelp bed.
2. Construct an artificial reef (for fish).
3. Habitat restoration or enhancement.
4. Information acquisition (in conjunction with other mitigation actions, particularly for hard-to-mitigate species).
5. Acquisition of coastal land.

The first two of these techniques represent in-kind replacement for resource losses. In-kind replacement of resources is the most preferred method of compensation, so it should be the method used for the majority of the resources and/or the most valuable resources. There are a number of problems associated with trying to apply in-kind techniques (Table 5). Two techniques seem particularly promising, however. In spite of the failure of most

previous attempts to create a kelp bed, this technique seems to be worth pursuing. Kelp beds are clearly an important habitat type in Southern California, and all government agencies seem to desire in-kind replacement of this habitat (see Appendix 3). There are some technical details to be resolved before this technique is implemented, however. A second important marine resource, fish, might also be replaced by an in-kind technique. A major impediment to utilizing artificial reefs as mitigation for the loss of fish resources is the lack of information about their function and their relationship to natural reefs. In fact, FWS has rejected several recent requests to use artificial reefs as mitigation because of the lack of information about them (J. Fancher, personal communication).

Although in-kind replacement is the most preferred mitigation technique, it is not feasible to exactly replace all the resources that might be impacted by SONGS. Furthermore, as mentioned above, the techniques for kelp bed creation are not well-established, and there is a serious lack of pertinent information about the value of an artificial reef. If future information indicates that these in-kind techniques are not adequate or feasible for achieving 100% compensation, out-of-kind techniques would have to be considered.

The three out-of-kind techniques listed above appear to be the best and most appropriate for SONGS. Habitat restoration or enhancement has previously been used extensively for resource compensation. The FWS and other agencies have experience with wetland restoration, so some of the technical problems have been

resolved. Although some problems still remain, including the difficulty of determining adequate compensation, habitat restoration seems likely to be considered the best out-of-kind technique available (see Appendix 3). The two remaining techniques listed above, information acquisition and coastal preservation, might not be considered appropriate mitigation under some circumstances (Ashe 1982). However, under the proper conditions both of these techniques could enhance the long-term biological and habitat resource values in Southern California.

The prevention of losses is generally the most favored technique for mitigation. In the situation at SONGS, however, loss prevention techniques cannot be integrated into project planning or construction. The implementation after construction of techniques involving structural changes would involve unknowns in the areas of engineering, biological effects, and economics. At present, the MRC doesn't know much about how structural changes would affect any of these areas. If the MRC makes the decision to consider mitigation techniques involving structural changes, much more detailed studies will need to be made to evaluate the techniques.

There are some loss prevention techniques that do not involve structural changes. Because most of the effects of SONGS result from the operation of the once-through cooling system, restricting the flow of water through the cooling system would reduce any impacts. Shutting down operations during seasons of high potential impact might also be effective at SONGS. However, other types of mitigation would seem to be better than seasonal restriction of

operation. This technique is only useful if the species at risk is a highly valued resource, and a predictable period of high risk can be avoided by restricted operations. For the major resources at risk at SONGS, it is not clear that predictable periods of high risk occur. Furthermore, the cost of this mitigation is on-going; it seems likely that an in-kind replacement of resources would be more cost-effective, particularly if it could be accomplished as a one-time expense.

Regardless of the technique(s) chosen for mitigation, it is important that some post-implementation evaluation be conducted. Although evaluation of the success of mitigation is frequently associated with mitigative actions, there are no established guidelines for evaluating a technique, and the time-span or effort allotted for evaluation is often inadequate. When the evaluation of a mitigative technique is inadequate, much valuable information that could be used for future applications of the technique is lost. The need for information about different mitigation techniques is particularly critical along the open coast, where there are very few previous applications to use for guidance. I strongly suggest that, regardless of the technique(s) chosen, the MRC recommend that appropriate evaluative studies be conducted.

CHAPTER 3

RECOMMENDATIONS FOR FUTURE STUDIES

The many unknowns associated with some of the techniques discussed in this report make it difficult, and perhaps unwise, to make decisions regarding their use for mitigation based on the current state of our knowledge. In this chapter, I recommend studies that I think will go a long way towards removing the uncertainty involved with utilizing these methods in mitigation. The MRC cannot study every aspect of each of the techniques listed in this report. Thus, I have focused on the few techniques for which MRC studies could have the greatest impact. Furthermore, this chapter deals primarily with in-kind mitigative measures, since these are generally considered to be the most preferred method of compensation.

The information needed to determine the feasibility of these mitigation techniques can be classified into three categories. First, information regarding the acceptability of using a particular technique for mitigation must be obtained. Although some of the techniques discussed could be implemented, it is not clear that they would be worth pursuing, since they might not work. For example, several techniques exist for providing in-kind compensation for possible losses of fish at SONGS, including a fish hatchery and restoration of nursery habitats; but what would be gained if hatchery-reared fish never successfully recruit into the

adult population? Second, for some techniques the procedures for implementing the techniques need to be refined. This information will help determine how the techniques would be implemented. For example, it would be valuable to know the best method for initiating a kelp bed. Finally, we need information for evaluating the success of a particular technique. For example, we need to know how productive an artificial reef is in order to know its mitigative value, and how large to construct one to achieve a particular value.

In the following discussion, I outline recommended studies that will assess the feasibility of selected mitigation techniques.

(1) Study the feasibility of creating kelp beds

The most promising method for compensating for the loss of kelp bed resources is to establish a new kelp bed. Efforts to establish self-sustaining kelp beds on artificial substrates have generally failed. In particular, kelp has not become established on the recent Pendleton Artificial Reef in spite of numerous transplant efforts. Consideration of previous attempts to establish kelp suggests that inappropriate environmental conditions (including the physico-chemical and biotic environment) and transplant techniques have contributed to these failures. I recommend that the MRC study these two aspects of establishing kelp beds.

(a) Techniques for establishing kelp

Much work has been done to develop methods for transplanting adult and juvenile Macrocystis (see Appendix 5). It seems likely that no further work on these methods is necessary. However, alternative methods for establishing kelp might be more efficient, cost-effective, or successful. For example, outplants of microsporophytes or gametophytes might work well. Dean has been using outplants of gametophytes and sporophytes in the San Onofre area, and has a well-established protocol (see Dean 1986). The MRC could compare alternative techniques to determine the optimal method, in terms of success and cost-effectiveness, for establishing kelp.

I recommend that the different techniques for establishing kelp be evaluated by a field experiment near San Onofre. Different techniques could be employed in replicate plots, with appropriate controls for natural recruitment of kelp. Techniques to consider include the transplant of adults, transplant of juveniles, outplant of microsporophytes, outplant of gametophytes, and transplant of fertile sporophylls. The study site should provide a large expanse of homogeneous substrate; Barn Kelp would be ideal, since stable kelp beds have occurred there in the past, but there has been virtually no natural recruitment of kelp there in the past few years.

The primary emphasis of this field experiment should be the evaluation of different techniques. However, it has been suggested that some seasons might be better for establishing kelp than others. Thus, the experiment could be repeated at several

different times of the year to investigate the influence of the seasons.

(b) Location and substrate for establishing kelp

Providing an appropriate substrate in the proper location will undoubtedly be vital for the successful establishment of a self-sustaining kelp bed. Previous attempts at establishing kelp on artificial substrates in Southern California have met with failure more often than success. Two aspects of the locations of these artificial reefs may have contributed to their failure. First, the physico-chemical conditions may not have favored the growth or recruitment of Macrocystis. For example, some reefs were placed in water that was too deep or too turbid for adequate light penetration (Ambrose 1985). Second, the biotic environment may not have been favorable. In particular, the isolated patches of transplanted kelp may have attracted an abundance of herbivorous fish. In addition, isolating the artificial reefs probably reduced the chances of natural recruitment by kelp, since kelp recruitment is generally very local (Anderson and North 1966). Both of these problems with location could be overcome by establishing new kelp beds adjacent to established kelp beds.

A field experiment designed to evaluate the potential of different locations would aid the planning of mitigation involving the establishment of a kelp bed. Since nearly all previous artificial reefs have been established in the middle of sand flats, I recommend that the MRC undertake a small, directed experiment

with only two locations tested: one in the middle of the sand, and one adjacent to an established kelp bed, such as San Mateo Kelp Bed. Small replicate reefs should be established at similar depths and exposures. Since the object would be to examine the effect of location on the growth and survival of kelp, the most promising technique or group of techniques should be used to establish kelp on the reefs. Control reefs at both locations would indicate the extent of natural recruitment of kelp.

(2) Study the production of fish on artificial reefs

An artificial reef is the most promising in-kind technique for mitigating the loss of fish. Much needs to be known about artificial reefs before their full potential can be realized in mitigation, but more importantly, our current state of knowledge actually limits the application of artificial reefs in mitigation. Among the most important information to gather is the relationship between the production of fish on natural and artificial reefs; this information is necessary to determine how extensive an artificial reef must be to provide 100% compensation.

(a) Survey natural and artificial reefs

One approach to comparing natural and artificial reefs is to survey existing reefs. The survey should collect information about fish recruitment and abundances (biomass), and thus should be timed to coincide with the major recruitment periods in spring and fall. All Southern California artificial reefs should be considered as

candidates for study, as well as all other man-made structures, such as breakwaters. The choice of artificial reefs is critical; only the most promising artificial reefs should be chosen for the survey. The choice of natural reefs for comparison is equally critical, since they should be as similar as possible to the artificial reefs. There are two possible approaches to a limited survey of this kind. First, a large number of different reefs can be surveyed infrequently. This approach has been taken by Jake Patton, who has surveyed 89 natural reefs (see Patton 1985). Second, a few reefs can be studied more thoroughly; this approach is more likely to give insight into the dynamical processes that occur on the reefs. A combination of the two approaches might provide the most information. The survey could also evaluate the influence of design features of the artificial reefs and compare the algal and invertebrate biotas of artificial and natural reefs.

(b) Studies on Pendleton Artificial Reef

Pendleton Artificial Reef is one of the best documented artificial reefs in the world. The MRC has already conducted intensive studies of PAR, but these were not directed specifically at the fish production question, and PAR has had several more years to develop since the conclusion of those studies. DeMartini (personal communication) has suggested that there may be feasible techniques for measuring fish production on PAR. At the very least, I recommend continuing to measure fish recruitment on PAR, since quantitative recruitment data have been collected on few

artificial reefs. In addition, the MRC might want to consider studying the extent of the influence of PAR, i.e. how far out onto the sand in the fish assemblage different due to PAR.

(c) Experimental artificial reefs

Many of the questions regarding artificial reefs could be answered with large-scale experimental reefs. A project of this magnitude is beyond the time and budget available to the MRC, and in the short term may not be very informative for fish production. On the other hand, it would provide information about fish and kelp recruitment, which would be useful for evaluating the feasibility of using artificial reefs as mitigative techniques. Because the DFG is planning to establish a large number of reefs along the Southern California coast, I propose that the MRC consider collaborating with DFG on the planning, and possibly follow-up studies, of these reefs. A well-designed experiment could provide valuable information within the next few years, at a minimal cost to the MRC.

(3) Determine critical life stages of fish species at risk.

Two possible techniques of in-kind compensation for losses of fish, a fish hatchery and restoring a nursery habitat, involve the early life stages of fish. Before these techniques can be recommended for use in mitigation, however, a great deal of information about the life history of the target species is necessary, and potential life-history bottlenecks must be identi-

fied, so that we can be reasonably certain that they will be effective in enhancing fish stocks. In addition, we should know which species, out of all candidate species, are most likely to respond to these mitigation measures. (The candidate species could include the species at risk at SONGS as well as any other species that might be considered for out-of-kind compensation, such as black sea bass.)

The initial study of the critical life stages of the candidate species could be accomplished by a detailed literature review and analysis. All available information from published sources and local experts should be gathered to determine which species, if any, are likely to benefit from the possible mitigation measures. Once this stage has been reached, modeling of the most promising species might prove valuable.

If the study of critical life stages indicates that a hatchery might be appropriate for particular species, a technical and economic feasibility study should be performed. (Note: the white sea bass hatchery might be in a position to provide good economic data by the end of the year.) Current data suggest that the technical problems associated with rearing many marine fish species can be solved fairly readily; before any decision regarding using hatcheries for mitigation would have to be made, more information will be available from the established hatchery programs in California.

Previous recommendations to the MRC regarding mitigation

As noted in the Preface to this report, the MRC has conducted a number of other studies dealing with mitigation. Reports for four of these studies have contained recommendations regarding mitigation. This section provides a brief summary of these previous recommendations to the MRC; for complete coverage of the recommendations, the original report should be consulted.

All of the reports containing recommendations for mitigation have emphasized artificial reefs. All previous studies have recommended that the MRC define its mitigation objective (Table 6); the authors have been particularly concerned with the level of involvement of the MRC. Sheehy (1981) suggested that the MRC consider transferring Japanese artificial reef technology for use in mitigation projects in California. Thum et al. (1983), in their thorough review of mitigation policy, recommended that the MRC take 18 policy stances regarding mitigation. Thum et al. (1983) also recommended that the MRC study the design and placement of artificial reefs, kelp production, and ways of manipulating the development of an artificial reef. LOSL (1983) recommended that the MRC study manipulation techniques for artificial reefs, plus continue studying PAR.

These previous recommendations cover a range of actions. All reports recommended that the MRC actively pursue mitigation. The reports also suggested field work that would help resolve some of

the questions regarding the feasibility of different techniques for mitigating the effects of SONGS.

A final recommendation

A significant obstacle to evaluating possible mitigation techniques in the marine environment is the lack of follow-up studies for techniques that have been implemented. A good local example is the artificial reef program in Southern California. Except for studies conducted more than two decades ago, and those performed by the MRC or funded by SCE, none of the artificial reefs constructed in Southern California has been thoroughly evaluated. Yet without a critical evaluation of a technique, no progress can be made towards more effective implementation in the future. Furthermore, without follow-up studies the successfulness of a particular technique cannot be determined. Follow-up studies are particularly important in a situation such as the open coast, where few mitigation techniques have been implemented previously.

The MRC should recognize the importance of evaluating any mitigation technique that might be implemented. I recommend that the MRC work to develop methods of evaluating any technique that may be considered for mitigating effects of SONGS.

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TABLE 1

Resource Categories and Mitigation Planning Goals

of the U.S. Fish and Wildlife Service

These four resource categories are described in the Fish and Wildlife Service Mitigation Policy (see Appendix 1). The principles guiding the mitigation planning goals are: (1) that avoidance or compensation be recommended for the most valued resources, and (2) that the degree of mitigation requested correspond to the value and scarcity of the habitat at risk. Thus, as the Resource Categories decrease in importance, the mitigation planning goals decrease in stringency. In keeping with the habitat-based philosophy of the FWS mitigation policy, the Resource Categories refer to habitats.

Resource Category	Designation criteria	Mitigation planning goal
1	High value for evaluation species and unique and irreplaceable.	No loss of existing habitat value.
2	High value for evaluation species and scarce or becoming scarce.	No net loss of in-kind habitat value.
3	High to medium value for evaluation species and abundant.	No net loss of habitat value while minimizing loss of in-kind habitat value.
4	Medium to low value for evaluation species.	Minimize loss of habitat value.

TABLE 2

Summary of Kelp Transplants to Artificial Reefs

Location	Date	Disposition	Possible Causes of Mortality
Santa Monica Bay Reefs	1959 1961	No plants survived	Fish grazing High water temperatures Water turbidity
Pendleton Artificial Reef	1980	Few plants survived Some recruitment in 1984	Fish grazing High water temperatures Inadequate light Space pre-emption
Neushul Mariculture Reef	1984	Good adult survivorship No recruitment	Storm-related mortality
Los Angeles Harbor Reef	1977	Initial mortality	Storm-related mortality Fish grazing
		Eventual success, spread of bed Good recruitment	
Natural recruitment to artificial reefs:			
Paradise Cove	1958	Good recruitment Persisted for several years Eventually disappeared, never reappeared	
Bureaucrat Reef	1975	Good recruitment Persisted two years Has not reappeared Several small plants seen in 1983	Storm-related mortality in winter 1978

TABLE 3

Fish species that use coastal wetlands in Southern California for spawning or nursery grounds (from Zedler 1982).

Location, source and sampling program	Dominant species	Resident species	Commercial spp. using wetland for spawning or nursery grounds
Tijuana Estuary Ford et al. (1971): 11 stations in Dec. 1970 + spring 1970 data of McIllwee (1970)	arrow goby cheekspot goby Ca. killifish topsmelt striped mullet	arrow goby Cheekspot goby Ca. killifish topsmelt striped mullet	California halibut diamond turbot kelp bass spotted sand bass barred sand bass
Upper Newport Bay Allen (1980): 3 stations, monthly from Jan. 1978-Jan. 1979	topsmelt Ca. killifish Ca. mosquitofish arrow goby deep body anchovy	topsmelt Ca. killifish Ca. mosquitofish arrow goby longjaw mudsucker	not assessed; possibly Anchoa sp. and diamond turbot
Anaheim Bay Lane & Hill (1975): various dates, 1971-1974	topsmelt gobies Ca. killifish deep body anchovy shiner surfperch	topsmelt Ca. killifish shiner surfperch staghorn sculpin goby species	deep body anchovy shiner surfperch California halibut diamond turbot
Ballona Wetland Swift & Frantz (1981): 13 stations, monthly from June 1980-June 1981	arrow goby Ca. mosquitofish topsmelt Ca. killifish longjaw mudsucker	arrow goby Ca. mosquitofish Ca. killifish longjaw mudsucker	diamond turbot?
Colorado Lagoon Allen & Horn (1975): 3 stations, monthly in 1973	northern anchovy topsmelt slough anchovy shiner surfperch	topsmelt shiner surfperch Ca. killifish staghorn sculpin slough anchovy	not assessed; possibly slough anchovy
Mugu Lagoon Onuf et al. (1978): 4 stations, 20 monthly samples, 1977-1978	shiner surfperch topsmelt staghorn sculpin Ca. killifish Ca. halibut diamond turbot white croaker bay pipefish longjaw mudsucker	topsmelt Ca. killifish Ca. halibut diamond turbot longjaw mudsucker grey smoothound bay blenny shadow goby	shiner surfperch Ca. halibut diamond turbot
Elkhorn Slough Nybakken et al. (1977): 4 stations, 23 months	surfperches flatfishes staghorn sculpin	not assessed	black surfperch white surfperch starry flounder & other flatfishes

TABLE 4

Status and future actions on wetland restoration projects in California (from Gates 1982).

COASTAL WETLANDS

PROJECT	PROJECT DESCRIPTION	AGENCY	PROJECT STATUS	FUTURE ACTIONS
Lake Earl/ Tawala, Del Norte	Complete acquisition of Lake Earl/Tawala	WCB	Negotiating for additional land acquisition	Unknown
McDonald Creek Humboldt	Restoration of riparian vegetation by acquisition of a conservation easement, planting riparian species, and fencing the area	SCC	In review process	Implementation in November 1982
Dry Lagoon/ Big Lagoon/ Stone Lagoon Humboldt	Complete acquisitions at Big Lagoon	DFG	Acquisition complete in January 1982	Develop general plan for all three lagoons including restoration as necessary
Elk River Humboldt	Elk River Restoration Plan—Restoration as part of a wastewater treatment project which allows expansion of the Eureka sewage treatment plant	City of Eureka/ DFG	In review process	Restoration anticipated in next few years
Tomales Bay Marin	Funding to run a series of citizens workshops to develop a watershed management program	SCC	In review process	Implementation in November 1982
Pescadero Marsh San Mateo	Acquisition of additional wetland areas in private ownership	DFG	Negotiating the acquisition	Unknown
Wilder Creek Santa Cruz	Designation of the creek already in public ownership as a nature preserve for snowy plover nesting. Acquisition of uplands around creek.	DFG	Negotiating the acquisition	Develop park facilities
Hills Ranch	Dedication of an easement to protect riparian vegetation as part of a coastal permit	SCC	To be completed	None
Laguna Grande/ Roberts Lake Monterey	Watershed management and park improvement/wetland restoration plan	Cities of Monterey & Seaside	Developing the plan	Plan completion and implementation
Elkhorn Slough Monterey	(a) Acquisition of additional uplands surrounding the estuary as part of the estuarine sanctuary program	DFG	Negotiating the acquisition	Inclusion in the sanctuary
	(b) Restoration and ongoing monitoring of a diked agricultural area	Researchers at Moss Landing Marine Labs	Construction started August 1981	Ongoing construction and research
Watsonville/ Pajaro Slough Santa Cruz	Land dedication to protect wetland from encroaching development	DFG	Negotiating the dedication	Unknown
Little Sur River Monterey	Acquisition of the lower river and floodplain and designation as a state reserve or natural preserve in State Park	DFG	Unknown	Unknown
Sweetsprings Marsh San Luis Obispo	Dedication or bargain sale of the marsh and surrounding uplands	SCC	Negotiating the acquisition	Development of a restoration plan
Pismo Lake and Ecological Reserve San Luis Obispo	Lawsuit against upstream developers for accumulated sediments in Lake	DFG	Ongoing	Unknown
Isla Vista Vernal Pools, Santa Barbara	Acquisition and enhancement of vernal pools and development of an educational program and preserve system for future acquisition/ dedication of vernal pools in the area	SCC & Isla Vista Parks & Rec. Dept.	Plan completed and funding allocated. Land negotiations in progress	Implementation of restoration plan.

WCB — Wildlife Conservation Board
SCC — State Coastal Conservancy
DFG — Department of Fish and Game
CCC — California Coastal Commission
USFWS — U.S. Fish and Wildlife Service
RWQCB — Regional Water Quality Control Board

TABLE 4 (Continued)

PROJECT	PROJECT DESCRIPTION	AGENCY	PROJECT STATUS	FUTURE ACTIONS
Carpinteria Marsh Santa Barbara	(a) Flood control project which will dredge channels and increase	Soil Conservation & Santa Barbara County	Plans completed but subject to review by CCC	Application for CCC permit in the next few months
	(b) Acquisition and restoration of historic wetland	SCC	Negotiating acquisition and developing plans	Completion of a restoration plan
Devreux Slough Santa Barbara	Restoration including methods to periodically or permanently breach mouth and control of upstream erosion	UCSB, DFG, USFWS	Developing the plan	Unknown
Goleta Slough Santa Barbara	Early planning stages of marsh restoration considerations and possible designation as an Ecological Reserve	DFG, City of Santa Barbara, SCC, UCSB	Under discussion	Unknown
McGrath Lake Ventura	Acquisition of dunes and uplands around lake	DFG	Partially funded	Unknown
Ormand Beach Ventura	Restoration and dedication as part of a coastal permit	Landowner or public agency	Under discussion	Application for CCC permit
Mugu Lagoon Ventura	Improvements to water circulation	Navy, USFWS	Restoration Plan complete but not funded	Unknown
Malibu Lagoon Los Angeles City	Restoration and expansion of salt water marsh	DFG	Restoration Plan complete and funding available. Delayed due to lawsuit.	Construction upon resolution of lawsuit
Los Cerritos Wetlands Los Angeles Cty.	Consolidation and enhancement of 130 acres of scattered degraded wetland	SCC	Site plan development	Implementation of a restoration plan as part of a development permit in the next 10-20 years
Seal Beach Wetlands Orange Cty.	Restoration of the scattered degraded wetlands onsite	SCC	Under review	Site plan development and implementation
Anaheim Bay Orange Cty.	Restoration of historic wetland to tidal marsh and improving circulation to existing wetland	USFWS	Under construction	None
Santa Ana River Mouth Orange Cty.	Acquire the tidal salt marsh and improve water circulation as mitigation for a flood control project	COE	Plan complete	Implementation will be at least 1986
Upper Newport Bay Orange Cty.	Restoration including dredging to remove sediment and upstream sediment basins	DFG	Plan complete and partially funded	Unknown
Los Penasquitos Lagoon San Diego Cty.	Develop plan to periodically breach the lagoon mouth	SCC, Sandag	Developing the plan	Implementation Summer 1982
Buena Vista Creek & Lagoon San Diego Cty.	Development of a plan to preserve and enhance the wetlands and riparian resources including legal instruments, a watershed management plan, a financing plan and acquisition of additional wetland	SCC, DFG	Watershed management plan under way and restoration plan being developed.	Implementation of watershed management plan
Batiquitos Lagoon San Diego Cty.	Acquisition of additional wetland	WCB	Negotiating the acquisition	Unknown

TABLE 4 (Continued)

PROJECT	PROJECT DESCRIPTION	AGENCY	PROJECT STATUS	FUTURE ACTIONS
San Elijo Lagoon San Diego Cty.	Acquisition and restoration by recontouring basins, installation of water control devices, supplementing freshwater with treated waste water and dike construction	San Diego County, DFG, RWQCB	Construction started Fall 1981	To be completed in 1982
San Dieguito Lagoon San Diego Cty.	Acquisition and restoration of fresh and tidal saltwater marsh by dredging remaining dikes, pumping groundwater	SCC, City of Del Mar, DFG	Plan complete, negotiating the acquisition	Implementation of part (if acquisitions are not successful) or all of the plan
Famosa Slough San Diego Cty.	Preparation of hydrologic studies in order to prepare restoration plan	SCC, City of San Diego	Hydrologic study to start in February	Determine method to protect wetland through
Tiajuana River National Estuarine Sanctuary San Diego Cty.	Acquisition and implementation of the Estuarine Sanctuary program for Tiajuana Estuary including interpretive center	OCZM, SCC, CCC	Land appraisals in process	Land negotiation and plans for interpretive center

SAN FRANCISCO BAY

PROJECT	PROJECT DESCRIPTION	AGENCY	PROJECT STATUS	FUTURE ACTIONS
Marsh Rd. Bayfront Park, San Mateo Cty.	Performed in conjunction with sanitary land fill; eventual restoration of 150 acres	City of Menlo Park	Some regrading, but no tidal activity; BCDC: 18-70	Site to be restored adjacent to planned Bayfront Park
San Pedro Cove	1.5 acre mitigation for San Rafael, Marin Cty.	Private condominiums	No work done; landowner	— BCDC: 27-77
Shoreline Center, Marin Cty.	0.19 acre mitigation for construction of office complex	Private landowner	Entire project delayed; BCDC: 35-79	May not be completed
Village Shopping Center, Marin Cty.	Mitigation for shopping center: multiple use as flood basin; improve water quality, and create habitat. 34 acres	Private landowner	Planning completed.	Construction anticipated in 1982
Coyote Hills marsh/treatment facility, Alameda Cty.	Test facility to demonstrate use of wetlands to treat urban runoff	ABAG (EPA 208)	Planning completed in cooperation with EBRPD	Construction underway
Pt. Edith, Contra Costa Cty.	Mitigation for fill; requires restoration of 20 acres in Carquinez Straits	DFG, SLC	Restoration not begun; BCDC: 15-79	Will participate as part of larger land bank
Ravenswood Triangle, San Mateo Cty.	Mitigation for Dumbarton Bridge construction.	Mid-Peninsula Open Space Dist.	$350,000 allocated	Planning, permits, and implementation
Inner Harbor Basin marsh, Contra Costa Cty.	Involves dredging, dike-breach, and planting for a 4.03 acre restoration	Richmond Redevelopment Agency	Planning completed BCDC: 11-78	Construction in conjunction with marina development
Coyote Creek Slough, Alameda Cty.	Mitigation for industrial park to create 265 acre lagoon/marsh system —	Private landowner	Planning completed; BCDC:	Project to be completed over several years; initial site to be used as borrow pit.
Hayward freshwater marsh, Alameda Cty.	Creation of 125 acre freshwater marsh on former salt evaporators. Will use treated effluent as freshwater source	EBRPD	Planning and permit process in progress	Awaiting SCC funding and final permits

TABLE 5

Summary of mitigation techniques

Technique	Considerations
In-kind Replacement	
Kelp bed restoration	May not be appropriate Technical problems
Kelp bed creation	Technical problems
Artificial reef	Inadequate information about fish production Questions about design
Fish hatchery Invertebrate hatchery	Inadequate life history info May not be effective Economics
Restore nursery habitat Manipulate habitats	Inadequate life history info Technical problems
Out-of-kind Substitution	
Habitat Restoration	Difficult to determine adequate compensation Technical problems
Coastal Preservation	May not be appropriate
Information Acquisition	May not be appropriate
Monetary Payments	May not be appropriate Difficult to determine adequate compensation
Water Quality Improvement	Difficult to determine adequate compensation
Loss Prevention	
Structural Modifications	Economics Unknown consequences
Flow Restriction	Economics
Seasonal Restriction	May not be effective

TABLE 6

Summary of previous recommendations to the MRC regarding mitigation

	Sheehy[1]	Thum[2]	LOSL[3]	Ambrose[4]
Define mitigation objective	X	X	X	X
Transfer Japanese technology	X			
Reef design and placement				
1) field survey				X
2) field experiment		X		X
Studies on production of fish				
1) field survey				X
2) field experiment				X
Studies on production of kelp				
1) experiment		X		X
2) techniques for establishing		X		X
Comparison with natural reefs				X
Manipulation techniques (post-construction transplants, etc.)		X	X	
Future studies of PAR			X	
Potential policy stances		X (18 recommendations)		

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[4]Ambrose, R.F. 1985. Artificial Reefs. Volume I, A Review and Analysis. Draft Report to the Marine Review Committee. 165 pp.

FIGURE 1

General Location of the San Onofre Nuclear Generating Station

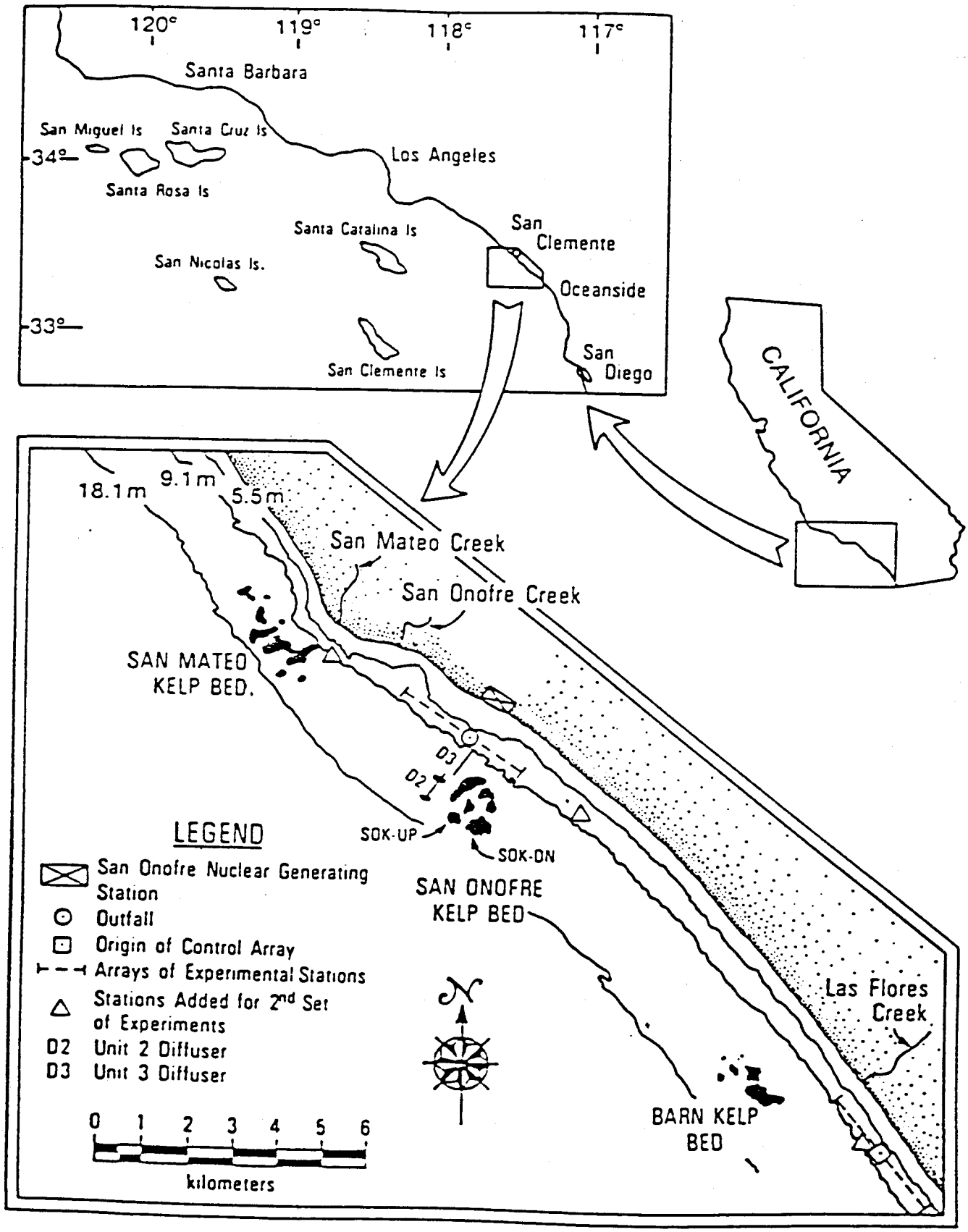


Figure 1. Chart of the general San Onofre region.

FIGURE 2

Locations of Wetlands in Southern California

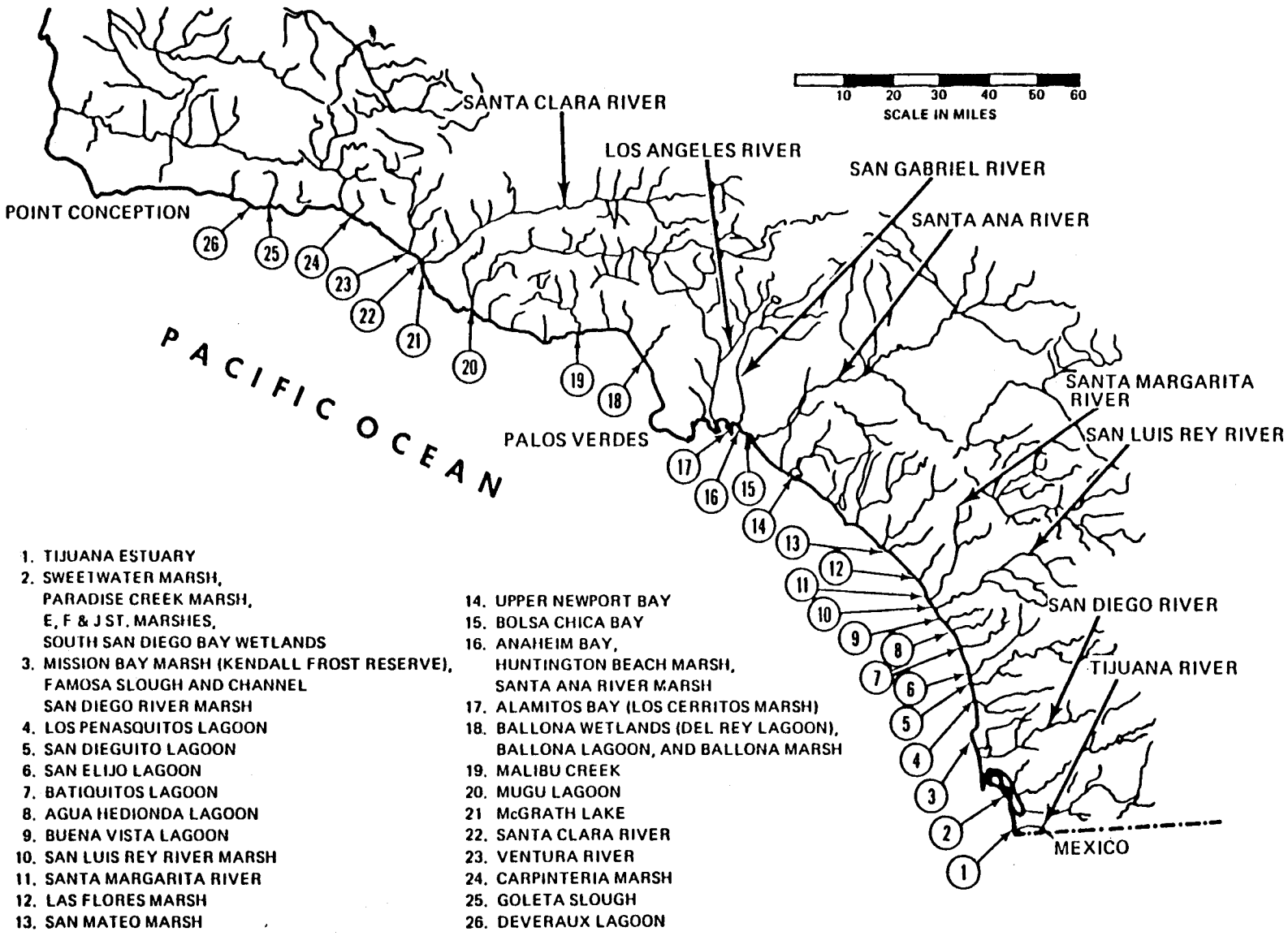
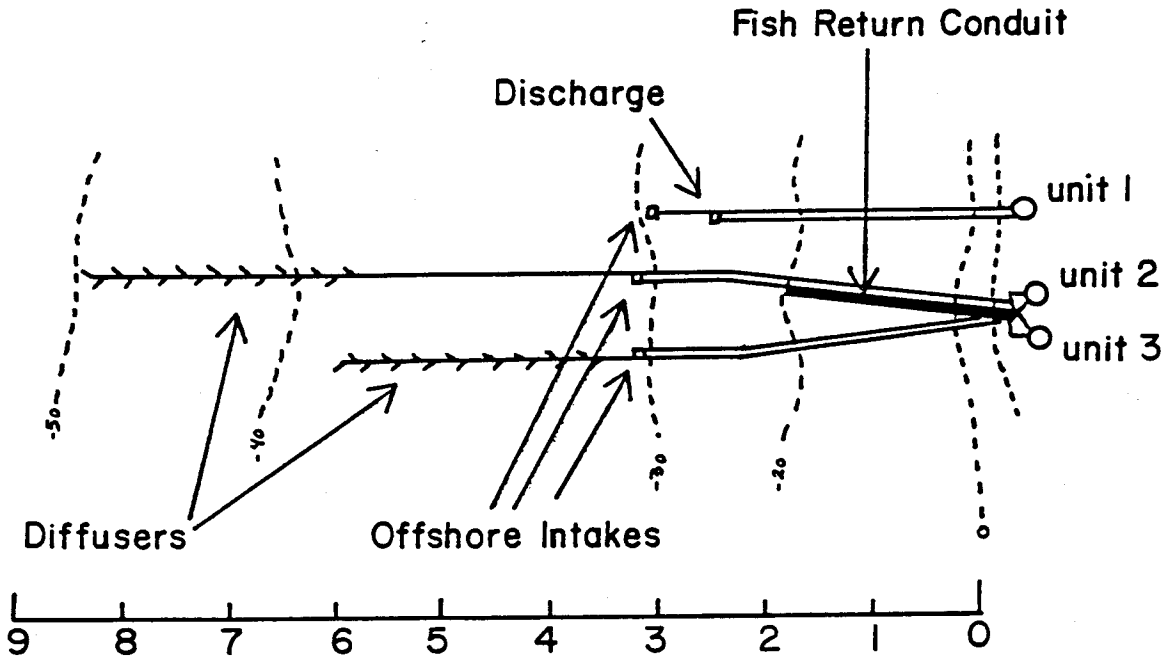


Figure . Location of southern California coastal wetlands and major rivers. (From Zedler 1982)

FIGURE 3

Locations of Intake and Discharge Systems at SONGS



DISTANCE FROM SHORE IN 1000 FEET

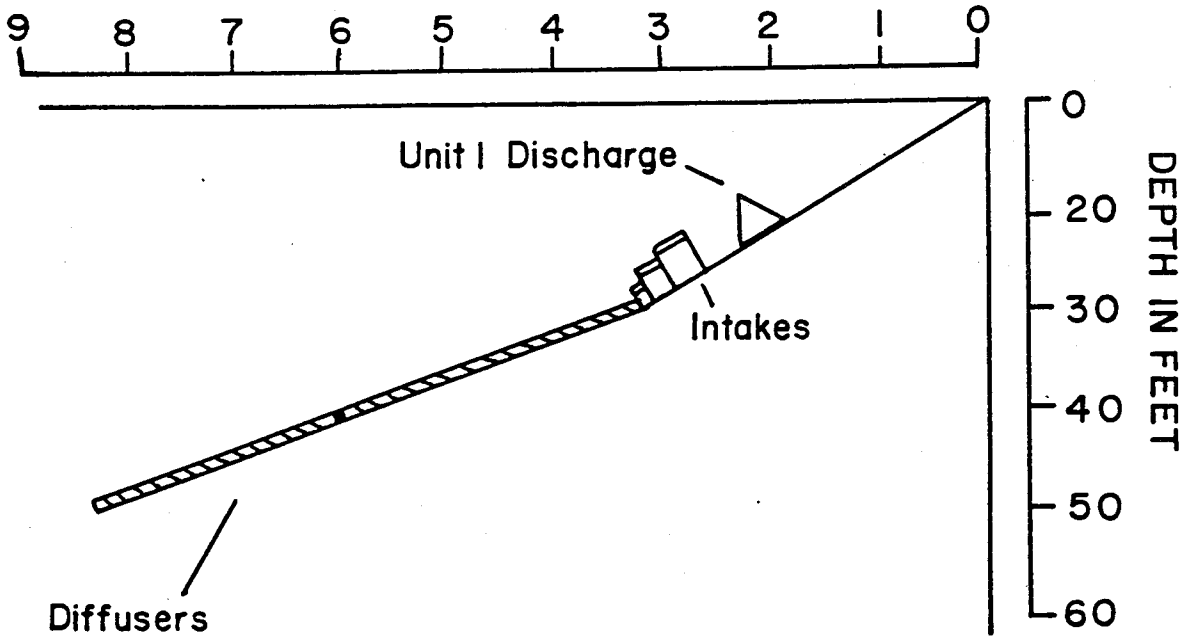


FIGURE 4

Diagram of the Fish Return System at SONGS

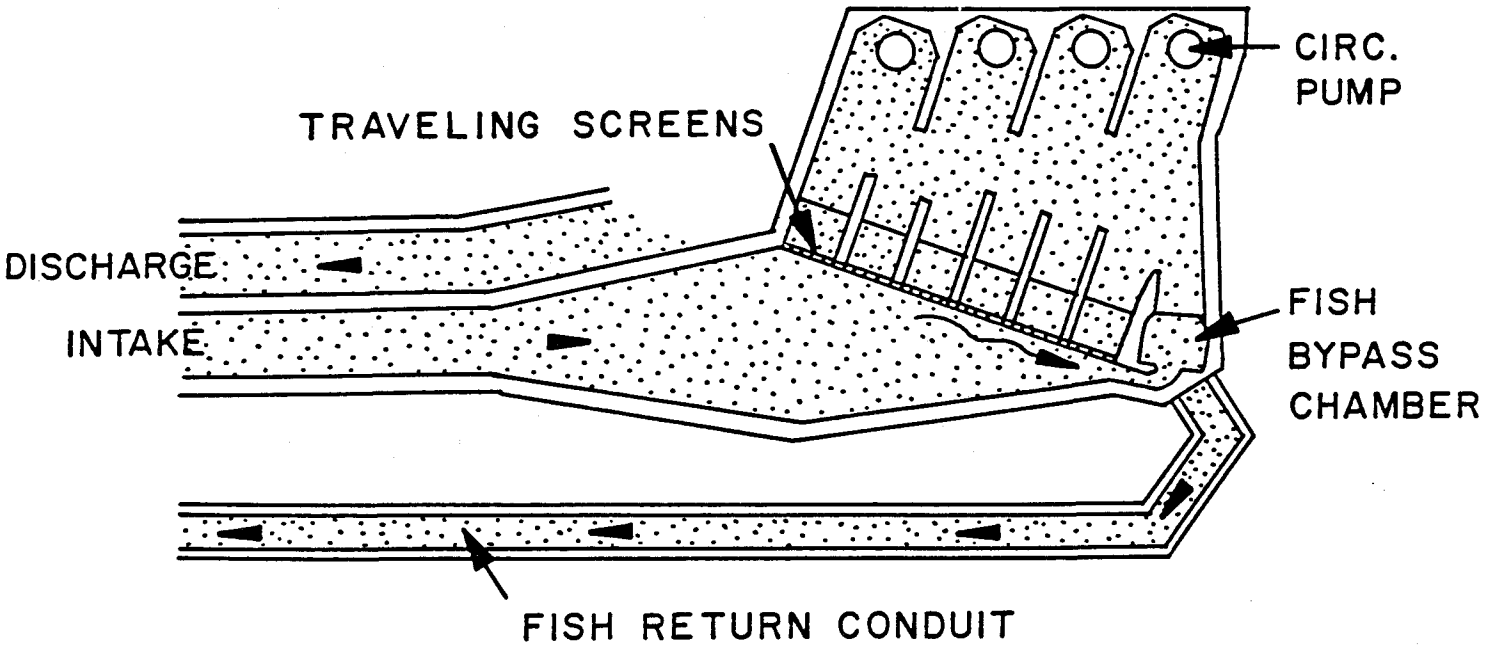
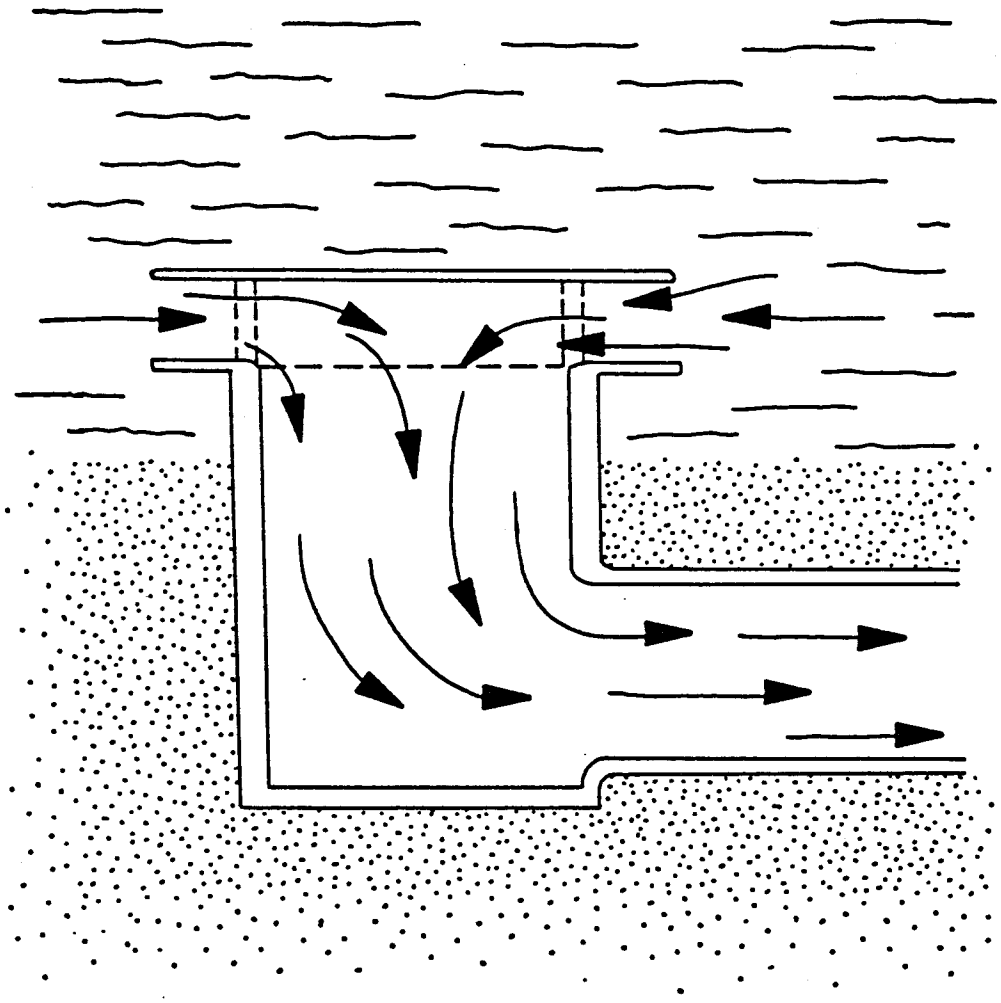

CIRC.
PUMP
TRAVELING SCREENS
DISCHARGE
INTAKE
FISH
BYPASS
CHAMBER
FISH RETURN CONDUIT

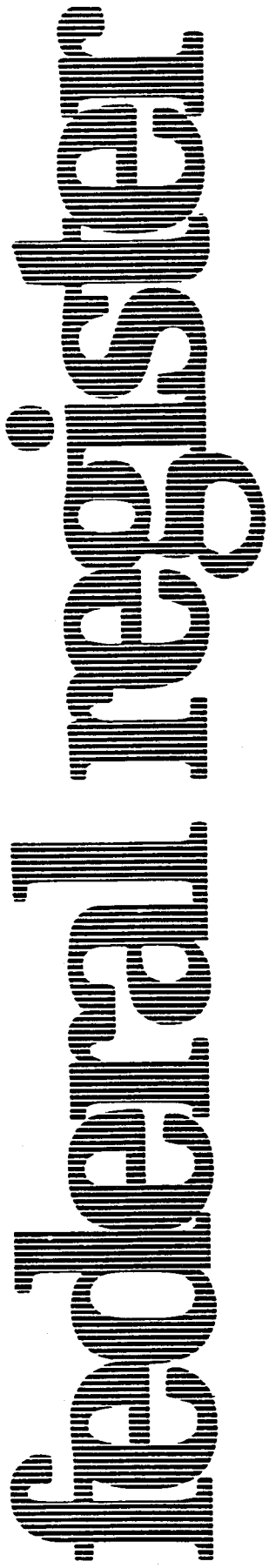
FIGURE 5

Diagram of the Velocity Cap at SONGS



APPENDIX 1

Mitigation policy of the U.S. Fish and Wildlife Service



Friday
January 23, 1981

Part III

Department of the Interior

Fish and Wildlife Service

U.S. Fish and Wildlife Service Mitigation Policy

[As corrected in the Federal Register of February 4, 1981]

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

U.S. Fish and Wildlife Service Mitigation Policy; Notice of Final Policy

AGENCY: U.S. Fish and Wildlife Service. Department of the Interior.

ACTION: Notice of Final Policy.

SUMMARY: This Notice establishes final policy guidance for U.S. Fish and Wildlife Service personnel involved in making recommendations to protect or conserve fish and wildlife resources. The policy is needed to: (1) ensure consistent and effective Service recommendations; (2) allow Federal and private developers to anticipate Service recommendations and plan for mitigation needs early; and (3) reduce Service and developer conflicts as well as project delays. The intended effect of the policy is to protect and conserve the most important and valuable fish and wildlife resources while facilitating balanced development of the Nation's natural resources.

EFFECTIVE DATE: January 23, 1981.

ADDRESS: Comments submitted on the proposed policy may be inspected in Room 738, 1375 K Street, N.W., Washington, D.C. 20005, between 9 a.m. and 3 p.m. on business days.

FOR FURTHER INFORMATION CONTACT: John Christian, Policy Group Leader—Environment, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240, (202) 343–7151.

SUPPLEMENTARY INFORMATION:

BACKGROUND

The development and use of the Nation's natural resources continues in an effort to provide people with their basic needs and to improve their lives. Fish and wildlife and the intricate fabric of natural resources upon which they depend provide benefits to people in many ways. Fishing, hunting, and bird watching are basic benefits that come to mind immediately. These activities involve the direct use of these renewable "natural resources." Perhaps a greater benefit, although more difficult for some to understand, is the maintenance of the structure and function of the ecosystem that comprises all living species, including people. The presence of diverse, healthy fish and wildlife populations generally signals a healthy ecosystem which contains those elements necessary for human survival, including unpolluted air and productive land.

That fabric of natural resources called habitat is the supply for fish and wildlife renewal. The life requirements for plant and animal species are varied and complex. Each species requires a different set of environmental conditions for survival and vigorous growth. These conditions form the habitat of the various species. The development and use of natural resources leads to changes in environmental conditions that can redefine habitat and thus change the mix and abundance of plant and animal species.

A given change in habitat might increase or decrease overall habitat productivity or result in gains or losses of species that are valuable to people or ecosystems. In some cases, habitat modifications can also increase the numbers of species considered undesirable, and create a nuisance to people or crowd out more valuable species. Therefore, development actions can cause habitat changes that are considered either beneficial or adverse depending on the intended wildlife management objectives.

When professional biologists determine that a given development action will cause a change that is considered adverse, it is appropriate to consider ways to avoid or minimize and compensate for such adverse change or loss of public resources. This is commonly referred to as mitigation.

Fish and wildlife resources are public in nature. The Service has provided Federal leadership for over 40 years to protect and conserve fish and wildlife and their habitat for the benefit of the people of the United States. Under its legal authorities, the Service conducts fish and wildlife impact investigations and provides mitigation recommendations on development projects of all kinds. These efforts have been conducted through a full partnership with State agencies responsible for fish and wildlife resources, and since 1970, with the National Marine Fisheries Service of the U.S. Department of Commerce. The recommendations of the Service are considered by the Federal development and regulatory agencies for their adoption as permitted by law.

Over the years, the Service has reviewed innumerable project and program plans with the potential to adversely affect fish and wildlife resources. The mitigation recommended in recent years by Service personnel to prevent or ameliorate adverse impacts has been governed primarily by a broad policy statement on mitigation promulgated in 1974 and by specific guidelines issued as needed. Recent events have prompted the Service to make known its mitigation objectives and policies. Specific management needs include:

(1) Recent legislative, executive and regulatory developments concerning the environment which have led to a need to update and expand the advice within the 1974 Service policy statement;

(2) Increasing Service review responsibilities which require issuance of comprehensive guidance on mitigation to maintain the quality and consistency of Service mitigation recommendations;

(3) An explicit summary of Service mitigation planning goals and policies to be disclosed to developers and action agencies to aid their earliest planning efforts; and

(4) Finally, the current national need to accelerate development of energy resources which requires that early planning decisions be made that can minimize conflict between important environmental values and energy development.

For these reasons, it was determined to be necessary to fully outline the overall mitigation policy of the U.S. Fish and Wildlife Service. The final Service policy statement integrates and outlines the major aspects of current Service mitigation efforts. Intended as an overview document, its guidance is based on an analysis of current Service field recommendations and on the guidance contained in recent Service management documents.

This policy conditions only the actions of Service employees involved in providing mitigation recommendations. It does not dictate actions or positions that Federal action agencies or individuals must accept. However, it is hoped that the policy will provide a common basis for mitigation decisionmaking and facilitate earlier consideration of fish and wildlife values in project planning activities.

Finally, it should be stressed that this Service policy outlines mitigation needs for fish and wildlife, their habitat and uses thereof. Others interested in mitigation of project impacts on other aspects of the environment such as human health or heritage conservation may find the Service policy does not fully cover their needs. There was no intent to develop a mitigation policy that covers all possible public impacts except those stated. However, the Service strongly believes that preservation and conservation of natural resources is a necessary prerequisite to human existence.

DISCUSSION

The following items are included to provide a better understanding of the policy's relationship to other guidance and to improve the understanding of its technical basis.

1. Relationship of Service Mitigation Policy to Other Service Planning Activities.

The final policy is designed to stand on its own. However, for a clearer perspective of the relationship of the policy to the goals and objectives of the U.S. Fish and Wildlife Service, it can be read with the Service Management Plan and the Habitat Preservation Program Management Document.

The Service Management Plan describes the overall direction of the Service and the interrelationships of the four major categories, including Habitat Preservation, Wildlife Resources, Fishery Resources, and Federal Aid-Endangered Species.

The Habitat Preservation Program Management Document outlines what the Service will do over a one- to five-year period to ensure the conservation and proper management of fish and wildlife habitat. It provides guidance to Service personnel and other interested parties on the goals, objectives, policies, and strategies of the Habitat Preservation Category of the U.S. Fish and Wildlife Service. It includes a discussion of important resource problems that the Service believes require priority attention.

2. Relationship of the Mitigation Policy to any future Fish and Wildlife Coordination Act (FWCA) Regulations and the National Environmental Policy Act (42 U.S.C. 4321–4347) (NEPA).

The Service mitigation policy outlines internal guidance for Service personnel for all investigations and recommendations for mitigation under relevant Service authorities, including the FWCA and NEPA. However, the coverage of the policy is basically different from that of any future FWCA regulations as was explained in the preamble to the proposed policy (September 9, 1980) (45 FR 59486–59494). Any future FWCA regulations will principally recommend procedures for all affected agencies to ensure compliance with that Act before and after they receive fish and wildlife agency recommendations. In contrast, the Service mitigation policy only applies to Service personnel and outlines mitigation planning goals and policies for impact analyses and recommendations.

The relationship of the mitigation policy to NEPA requirements is also a complementary one. The regulations implementing NEPA (43 FR 55978–56007) recognize "appropriate" mitigation recommendations as an important element of the rigorous analysis and display of alternatives including the proposed action (40 CFR Part 1502.14). The NEPA regulations later specify that Service impact analyses and mitigation recommendations shall be used as input to preparation of draft environmental impact statements (DEIS) as follows:

"To the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.), the National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.), the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), and other environmental review laws and executive orders." (40 CFR 1502.25(a)).

These provisions provide clear direction that NEPA requirements are not duplicative of or substitute for mitigation recommendations developed under the Fish and Wildlife Coordination Act and other Service authorities. In fact, the NEPA regulations require that Service recommendations be fully integrated into the NEPA process as vital information necessary to comply with NEPA.

3. Focus of the Policy on Habitat Value.

The policy covers impacts to fish and wildlife populations, their habitat and the human uses thereof. However, the primary focus in terms of specific guidance is on the mitigation of losses of habitat value. Population estimates are considered by many to be unreliable indicators for evaluating fish and wildlife impacts. Sampling errors, cyclic fluctuations of populations and the lack of time series data all contribute to the problem. Therefore, the Service feels that habitat value, by measuring carrying capacity, is a much better basis for determining mitigation requirements. However, the use of population information is not foreclosed by the policy. In fact, concern for population losses led to formulation of the "General Policy" section to ". . . seek to mitigate all losses of fish, wildlife, their habitat and uses thereof . . ." The Service agrees that mitigation of population losses is a necessary aspect of this policy, for example, when habitat value is not affected but migration routes are blocked off as in the case of dam construction on a salmon river.

Mitigation of human use losses of fish and wildlife resources is also a necessary aspect of the policy. However, if mitigation of habitat value occurs, then in the majority of cases, losses of human use are also minimized. But, in some cases, public access to the resource may be cut off by the project and significant recreational or commercial benefits may be lost.

In those cases where mitigation of habitat value is not deemed adequate for losses of fish and wildlife populations or human uses, the Service will seek to mitigate such losses in accordance with the general principles and concepts presented in the policy. However, in the majority of cases, the Service feels that mitigation of impacts on habitat values will assure a continuous supply of fish and wildlife populations and human use opportunities.

The Service has recently revised and updated its *Habitat Evaluation Procedures* (HEP). It can be used, where appropriate, to determine mitigation needs based on habitat value losses. In some cases, the project may not be deemed appropriate for applying the methodology as in the case of activities conducted on the high seas under the Outer Continental Shelf (OCS) leasing program. In such cases, the use of other methods to describe habitat value impacts is clearly acceptable, including the best professional judgment of Service biologists. Other limitations related to the use of HEP are outlined in the Ecological Services Manual (100 ESM 1). The HEP are available upon request from the Chief, Division of Ecological Services, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240.

4. Acre for Acre Loss Replacement Is Not Necessarily Recommended by the Policy.

As explained above, the policy focuses on habitat value. The habitat value of an acre of habitat can vary considerably depending on the type of vegetation and other physical, biologic or chemical features. Service recommendations, therefore, will be based on the habitat value adversely impacted, as opposed to strictly acreag For example, loss of one acre of a specific type of wetland might result in recommendations for replacement of less than one acre of a different type of wetland of greater habitat value. If the habitat value of the wetland available for replacement was equal to that lost, then recommendations could be on an acre-for-acre basis.

5. Rationale for Mitigation Planning Goals.

In developing this policy, it was agreed that the fundamental principles guiding mitigation are: 1) that avoidanc or compensation be recommended for the most valued resources; and 2) that the degree of mitigation requested

correspond to the value and scarcity of the habitat at risk. Four Resource Categories of decreasing importance were identified, with mitigation planning goals of decreasing stringency developed for these categories. Table 1 summarizes all categories and their goals.

Table 1: Resource Categories and Mitigation Planning Goals

Resource category	Designation criteria	Mitigation planning goal
1	High value for evaluation species and unique and irreplaceable.	No loss of existing habitat value.
2	High value for evaluation species and scarce or becoming scarce.	No net loss of in-kind habitat value.
3	High to medium value for evaluation species and abundant.	No net loss of habitat value while minimizing loss of in-kind habitat value.
4	Medium to low value for evaluation species.	Minimize loss of habitat value.

POLICY HISTORY

The policy statement integrates and outlines the major aspects of current Service mitigation efforts. Intended as an overview document, its guidance is based on an analysis of over 350 Service field recommendations and on the guidance contained in recent Service management documents. The proposed policy was published in the Federal Register on September 9, 1980 (45 FR 59486–59494). A correction notice which corrected insignificant formatting and typographical errors was published on September 19, 1980 (45 FR 62564). A notice extending the comment period on the proposed policy to November 10, 1980, was published on October 8, 1980 (45 FR 66878). The final publication is based on full and thorough consideration of the public comments as discussed below.

RESPONSE TO COMMENTS

Over 90 sets of comments were received on the proposed policy. All comments were thoroughly analyzed and cataloged and considered. Many commentors expressed agreement with Service publication of the policy, sensing a more consistent and predictable Service approach to mitigation recommendations and a resultant decrease in the degree of conflict with developers. Many felt the policy represented a rational approach to fish and wildlife resource management, and that it would provide for adequate protection and conservation of the Nation's fish and wildlife resources. The underlying concept that the degree of mitigation requested should correspond to the importance and scarcity of the habitat at risk was also supported by many commentors. Numerous commentors also praised its scope, cohesiveness and clarity, and stressed that it should provide valuable guidance for Government personnel providing technical and project planning assistance.

Detailed responses to significant comments follow:

GENERAL COMMENTS ON THE PROPOSED SERVICE MITIGATION POLICY

Comment: Although the Service prepared an Environmental Assessment and, from its findings, concluded that policy issuance did not constitute a major Federal action which would significantly affect the quality of the human environment within the meaning of Section 102(2)(C) of the National Environmental Policy Act (NEPA), a few commentors disagreed with the Service's conclusion that an Environmental Impact Statement (EIS) was not necessary for the proposed action.

Response: During policy development, the Service took action to determine if preparation of an environmental impact statement under NEPA was required. Although section 1508.18 of the Council on Environmental Quality's (CEQ) Regulations for implementing the procedural provisions of NEPA classified adoption of an official policy as a "Federal action," it remained unclear as to whether this action was "major," or whether it would "significantly" affect the quality of the human environment, since policy implementation would not result in or substantially alter agency programs. As was stated in the preamble, this policy is basically a distillation of approaches and policy currently being practiced by Service field personnel in providing mitigation recommendations.

In order to resolve this uncertainty, an Environmental Assessment was prepared for the proposed and final policy. By doing so, the Service has complied with one of the major purposes of the NEPA regulations, which is to have NEPA applied early in the decisionmaking process.

The NEPA regulations do not, in the opinion of the Service, require that the agency speculate on future, possible events without any relation to actual, existing impacts of an action. Section 1502.2 of the NEPA regulations directs that an EIS is to be analytical, however, the Service action simply does not create any impacts capable of such analysis. Thus, there is no reasonable or scientific way for the Service to analyze any environmental impacts, significant or otherwise, as discussed in §§ 1502.16 and 1508.27.

This problem is particularly vexsome when those impacts depend on future contingencies and can be more appropriately analyzed when those contingencies occur. Even § 1502.4, which discussed EIS's in terms of broad agency actions, does so in the context of specific impacts caused by the action. In the opinion of the Service, it has fully complied with the letter and spirit of NEPA and its regulations.

Comment: One commentor felt that the preamble statement that an EIS would be premature at this time contradicted a finding of no significant impact.

Response: The Service sees no contradiction with a finding of no significant impact and the statement that an EIS is premature. The finding of no significant impact derives from an analysis showing that the policy has no significant impacts amenable to analysis at the present time. However, when in the future the Service does apply the policy in developing mitigation recommendations for a major Federal action which might significantly affect the quality of the human environment, then the environmental impacts associated with implementing those recommendations which are considered justifiable by the development agency can be analyzed by that development agency. The Service has no way of predicting which of its recommendations will be accepted by the developer; therefore, analysis of impacts of accepted mitigation recommendations is the responsibility of the developer.

Comment: One commentor was of the opinion that an EIS "should be prepared for the Service's proposed mitigation recommendations on each project." Moreover, the commentor felt that a significant portion of these EIS's should be devoted to analysis of economic impacts.

Response: Mitigation recommendations and actions cannot be meaningfully analyzed except in the context of the development action initiating them. And, since an EIS would be required for any major Federal action which would significantly affect the quality of the human environment and whose alternatives would include consideration of mitigation, a separate EIS would not be necessary for mitigation actions.

Under the FWCA, the action agency which makes the ultimate decision is to include all "justifiable mitigation means and measures" in project formulation. The burden of analyzing the economic impacts of "justifiable" mitigation measures therefore rests primarily with

the project sponsor, who will likely use the Water Resources Council's Principles and Standards to assist in the analysis.

Comment: The substantive requirements of the Service mitigation policy should be consistent with the requirements of the National Environmental Policy Act's implementing regulations and the Water Resources Council's Principles and Standards.

Response: We agree. The proposed and final policy have been developed consistent with the substantive and procedural requirements of these regulations.

Comment: The Environmental Assessment identifies as one of the advantages of the proposed mitigation policy the establishment of "* * * minimum performance standards for FWS recommendations (which) would serve as benchmarks by which the FWS and developers or action agencies * * * could assess individual Service mitigation proposals." However, neither the Federal Register notice nor the Environmental Assessment identify or discuss these "benchmarks."

Response: The term "benchmarks" referred to the mitigation goals and planning procedures. Both the proposed policy preamble and its Environmental Assessment discussed these guidelines, explaining their derivation and importance to policy purposes. However, a point of clarification is needed regarding these guidelines. It is the recommendations made by Service personnel that would be measured against these standards, not the mitigation implemented by an action agency. The final policy makes this point explicit.

Comment: Many commentors argued that the proposed policy goes beyond that authorized by law. Specific concern was expressed over the use of words that were mandatory in tone (e.g., "require" and "must") as opposed to advisory. In addition, some commented that the Service has no authority to support or oppose projects as stated in the policy.

Response: The Service agrees that the legal authorities for the mitigation policy do not authorize the Service to exercise veto power over land and water development activities. That understanding was implicit in the proposed policy. Appropriate changes have been made in the policy to more explicitly recognize and signify the advisory nature of the Service responsibility.

However, it should be clearly noted that the Fish and Wildlife Coordination Act places clear mandatory requirements on Federal development agencies falling under that Act's authority to (1) consult with the Service, National Marine Fisheries Service (NMFS) and State agencies responsible for fish and wildlife resources; (2) incorporate such reports and recommendations in one overall project report; (3) provide "full consideration" of the "reports and recommendations;" (4) include in the project plan "such justifiable means and measures for wildlife purposes as the reporting agency finds should be adopted to obtain overall maximum project benefits;" and (5) other requirements related to funding and land acquisition.

The clear intent of Congress was that recommendations developed by the U.S. Fish and Wildlife Service, NMFS, and State agencies responsible for fish and wildlife resources be taken seriously, and we know of no law which prohibits the Service from taking a position for or against a project when making mitigation recommendations.

Comment: The policy will adversely impact developmental interests.

Response: The goal of the policy is to provide for equal consideration of fish and wildlife conservation while facilitating development.

Congress has clearly stated that "wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs" (Pub. L. 85–624, Fish and Wildlife Coordination Act). This advice is further amplified in Senate Report 1981 on the FWCA (84th Congress, 2nd Session (1958)). The Congress recognized that in some instances, the level of dollar benefits to some purposes might have to be diminished "in some slight degree" in order to accomplish the fish and wildlife conservation objectives of the Act.

However, policy issuance should benefit developmental interests. By providing developers with a clear picture of Service mitigation concerns and priorities, the policy will allow developers to anticipate Service mitigation recommendations prior to final decisions on project design and location. By reducing a developer's planning uncertainties, the policy will result in lowered project costs and fewer project delays and conflicts.

Comment: Does the policy present general guidance or minimum required standards? The Service appears to be trying to establish required standards.

Response: The final policy sets out mitigation goals and planning guidance to guide the development of Service mitigation recommendations. It does not require absolute strict adherence to a required standard. Changes have been made to reflect this.

Comment: No mention is made of the State role in mitigation planning to assure a compatible approach. The States' authorities and decisionmaking prerogatives with respect to fish and wildlife resources should be denoted and the States' roles in mitigation should be emphasized further.

Response: A compatible approach is desirable. We have included appropriate changes. However, the policy is solely for Service personnel. There is no intent to infringe on the States' prerogatives.

Comment: The policy should require full public disclosure of Service mitigation analyses, determinations, and recommendations.

Response: We agree that full disclosure of Service analyses, determinations and recommendations during the mitigation process would serve the public interest. All public documents associated with Service recommendations for mitigation on specific land and water developments are available for review in Ecological Services field offices. No change in the policy is necessary.

Comment: The Service should specifically address the acid rain problem in its policy. In particular, the policy should address the impact of Federal policies and programs that support power plant conversions to coal.

Response: The Service currently reviews such Federal actions under NEPA, since these policies and programs are likely to require an EIS. Because acid rain has been highlighted as an Important Resource Problem (IRP) by the Service, environmental analyses which do not adequately address acid rain problems will receive particular attention by Service reviewers. Our comments will be technically reinforced by Service research already being conducted in this area. Since the policy already covers this issue, no change is necessary.

Comment: Could the mitigation policy call for a recommendation as extreme a reflooding of the Mississippi River Valley?

Response: The mitigation policy would not lead to so extreme a recommendation because it does not apply to development actions complete prior to enactment of Service authorities or exempted by those authorities. In those situations where the policy does apply, there will be no recommendation for mitigation over and above the level of impacts associated with a project. This policy acts to minimize impacts of projects, not reverse them.

Comment: Which agency enforces the policy and what power does it have?

Response: This is a policy that applies only to Service personnel. It does not predetermine the actions of other Federal agencies, nor the actions of State agencies or developers. Although the policy statement is not judicially enforceable, the Service will administer the policy by monitoring the mitigation recommendations made by its own personnel.

Comment: Too often land acquired for mitigation does not provide the spectrum of resource values previously available because the managing agency's philosophy prevents it from managing the land for a mix of goals.

Response: Lands acquired for mitigation purposes must provide the specific mitigation benefits for which they were intended. Secondary land uses, such as provision of timber, oil and gas exploration, or recreational benefits, should be attempted where these uses are compatible with the mitigation lands' primary purpose. This concept has been added to the policy.

SPECIFIC COMMENTS ON THE MITIGATION POLICY

(These comments are keyed to sections of the proposed policy.)

I. Purpose

Comment: Why is this policy apparently unconcerned with flora?

Response: Mitigating for fish and wildlife losses necessarily means dealing with the plant communities on which all animal life indirectly depends. When habitat is preserved, it is the plant communities that are the vast bulk of the living material of that habitat.

Plants *per se* are addressed by other authorities of the Service which are not within the scope of this policy, such as the Endangered Species Act and associated regulations.

II. Authority

No significant comments.

III. Scope

Comment: How does the policy affect projects already completed or under construction?

Response: Appropriate changes in the Scope section have been made to clarify policy coverage with regard to completed projects or projects under construction.

Comment: Since Federal permit renewals will result in no new effects on the environment, they should be exempt from the policy.

Response: The permit or license renewal process provides an opportunity to re-evaluate the project. Depending on new scientific information concerning impacts, the adequacy of past developer mitigation efforts, or new authorities, new mitigation recommendations may be necessary.

Not infrequently, permit or license holders use the renewal process as a convenient occasion to seek changes in their permits. Any changes in permit or license holders' activities have to be evaluated to determine whether or not they necessitate new mitigation recommendations.

This policy, therefore, will be used by the Service in permit or license renewal proceedings, keeping in mind that Service recommendations are advisory to action agencies. Appropriate changes were made in the policy to reflect this position.

Comment: Does this policy apply to man-induced wetlands?

Response: Where the Service has the authority and responsibility to recommend mitigation for these habitats, the tenets of the policy shall apply.

Comment: There is a need for a mechanism for evaluating enhancement and a means to differentiate it from mitigation.

Response: Although enhancement is an important concern of the Service, the Service mitigation policy should not serve as the primary vehicle for discussing enhancement. The final policy does differentiate between enhancement and mitigation recommendations by defining enhancement to include measures which would improve fish and wildlife resources beyond that which would exist without the project and which cannot be used to satisfy the appropriate mitigation planning goal. As for evaluating enhancement, it would appear likely that many of the procedures that can be used to evaluate mitigation can be used to evaluate enhancement.

Comment: What is the basis for the policy position that enhancement cannot occur until all losses are compensated? There is no legislative history for this.

Response: Unfortunately, the term "enhancement" suffers from wide differences in semantic usage. The proposed policy used the term to be synonymous with improvements beyond the achievement of full mitigation. This strict interpretation appeared to spark controversy.

The final policy incorporates a different usage of the term. Enhancement is used to describe measures not necessary to accomplish mitigation purposes.

Comment: The policy should credit towards mitigation goals those habitat value increases associated with areas of the habitat which are enhanced by the project. Habitat value should be computed for enhancement activities, and the inclusion of habitat enhancement factors would provide for a more accurate estimate of the project's impact on the environment.

Response: Use of the term "habitat enhancement" to describe development or improvement efforts is confused by this comment. The mitigation policy does not cover enhancement as we have described it. However, where habitat improvement or development caused by a project will result in habitat value increases, it may be considered as mitigation when consistent with the resource category designation criteria and the appropriate mitigation planning goal.

Comment: There should be a clear statement that all opportunities for enhancement of fish and wildlife resources be thoroughly considered and included in project plans to the extent feasible.

Response: We agree. Appropriate changes were made.

IV. Definition of Mitigation

Comment: Some commentors indicated concern over the definition of mitigation as used in the policy. Specific concern was expressed that those aspects of project planning that include avoidance or actions to minimize impacts should be considered good project planning and that mitigation should be confined solely to actions to compensate for resource losses.

Response: The Service agrees that avoidance or actions to minimize impacts should be part of the early design of projects and not just an afterthought. Some consider mitigation to be a separate and distinct process that occurs after project planning has been completed. The legally binding definition of mitigation as used in the regulations to implement the National Environmental Policy Act (NEPA) can have the effect of altering this notion through incorporation of all those actions that can lessen project impacts throughout the planning process.

The policy has been modified to more clearly state that the Service supports and encourages incorporation of features that will reduce adverse impacts on fish and wildlife resources as part of early planning and project design in order to avoid delays or conflicts. But without the emphasis on avoidance and minimization provided by the NEPA regulations' definition, there would be little incentive for development agencies to incorporate such features. The Service, therefore, supports and adopts that definition.

V. Mitigation Policy of the U.S. Fish and Wildlife Service

Comment: A number of documents are referred to in the draft policy. They are essential to the functioning of the policy and should be published as an appendix and otherwise made available for public comment, including public hearings.

Response: The preamble to the proposed policy clearly indicated that the policy was designed to stand on its own. The referenced documents are not essential to the functioning of the policy. For instance, even though Service field personnel will rely basically on the *Habitat Evaluation Procedures* in conducting project analyses, the policy indicates that other methods can be used where appropriate and available. The concept of habitat value has been recognized throughout the history of fish and wildlife management. It is not new.

Regardless of the fact that the policy stands on its own, the referenced documents have undergone varying degrees of public scrutiny independent of the mitigation policy. For instance, a notice of availability and request for public comment was published in the **Federal Register** for the Service Management Plan and Program Management Document on September 29, 1980 (45 FR 64271–64272). A habitat-based evaluation methodology has been under active development in the Service since 1973. The first document officially called the *Habitat Evaluation Procedures* was published in 1976 with the most recent revision in 1980. During this 7 year period, the Nation's top wildlife biologists have been consulted, both within the government and outside. The procedures have been presented at numerous public conferences and have been the subject of intense scrutiny.

Finally, the referenced documents were made available to reviewers. Over 75 requests were made and immediately filled to allow commentors the full benefit of this information in preparing comments, including the group providing this comment. Minor changes were made in the policy to more clearly indicate that the policy can stand on its own.

A. General Principles

Comment: Pursued to its logical conclusion, the concept of fish and wildlife as public trust resources could lead to serious restrictions on the use and management of private lands.

Response: When the concept of personal property rights is exercised in such a way as to jeopardize the interests of the public in fish and wildlife resources on public or private lands, the government may use its authorities to see that any damage to those interests is prevented or mitigated.

The Service does and will attempt to fulfill its duties within its authorities and in a reasonable manner. It is certainly cognizant of the fact that pursuing any concept to its logical extreme may lead to unreasonableness, and will continue to strive to prevent this from happening in its mitigation activities.

Comment: What does "equal consideration" of wildlife conservation mean within the context of the Fish and Wildlife Coordination Act and this mitigation policy?

Response: "Equal consideration" was not defined in the Act or this policy, and has no particular meaning in the context of this policy. This policy only covers Service recommendations, not action agency requirements.

Comment: The proposed Service policy now absolutely precludes support for non-water dependent projects within or affecting waters of the United States. This should be modified to conform to the requirements of Federal regulatory agencies such as the Army Corps of Engineers (COE) and the Environmental Protection Agency (EPA).

Response: The Service policy clearly does not exercise veto power over development actions. Moreover, the Service will execute its responsibilities fully within the context of existing laws and regulations governing environmental reviews. However, the Service feels that wetlands and shallow water habitats should not be subjected to *needless* development because of the public values of these areas. The Service policy statement does not include water dependency as the "sole" criterion for its recommendations. Other factors, including the likelihood of a significant loss, are considered prior to a Service recommendation for support of a project or the "no project" alternative.

The provisions of the policy have been modified to make such recommendations discretionary.

Comment: Congress, not the Service, is the entity that has the authority to require and fund compensation for Federal projects.

Response: We agree. The policy has been modified.

Comment: Mitigation should not be required for an indefinite period of time.

Response: Mitigation is appropriate for the entire time period that habitat losses persist, which includes the life of the project and as long afterwards as the impacts of the project continue to exist. The policy reflects this position.

Comment: Under "General Principles," the policy should seek and endorse novel or imaginative approaches to mitigation.

Response: The Service fully supports development of novel and imaginative approaches that mitigate losses of fish and wildlife, their habitat, and uses thereof, and has been in the forefront of such development. No change is necessary.

Comment: An Indian tribe strongly supports the Department of the Interior's recognition of the role of Indian tribal governments in mitigation planning.

Response: Our national heritage and, in some cases, the livelihood of Indian tribes, can be directly linked with the conservation and use of fish and wildlife resources. Therefore, the U.S. Fish and Wildlife Service will continue to recognize and support Indian tribal governments' efforts to mitigate impacts on these resources.

B. U.S. Fish and Wildlife Service Mitigation Goals by Resource Category

Comment: The mitigation goals for the resource categories were characterized as: reasonable, too strict, or not strict enough.

Response: As was explained in the preamble to the draft policy, the resource categories and their mitigation goals were abstracted from an analysis of actual field recommendations. The designation criteria for the resource categories (replaceability, scarcity, and value for evaluation species) are the basic decision factors used by Service personnel to assess relative mitigation needs. The mitigation goals represent reasonable mitigation expectations for projects, viewed in the light of our two-faceted goal—(1) to conserve, protect and enhance fish and wildlife and their habitats, and (2) to facilitate balanced development of our Nation's natural resources.

Numerous comments were received commending us on the balanced approach embodied in this policy. Since its tenets derive from field recommendations and comments, the credit belongs entirely to our field staff.

Some commentors criticized the mitigation goals. One group felt that one or several of the mitigation goals were too strict. These commentors objected to what they considered to be unreasonably high goals for fish and wildlife mitigation. In contrast to this first group, another set of commentors felt that the goals were not strict enough, and called attention to our legislative responsibility to seek protection for all fish and wildlife resources.

Our response is that the mitigation goals represent the best professional judgment and cumulative experience of Service field supervisors in developing mitigation proposals that would satisfy

our legislative mandates, operate under time and money constraints, and assist in maximizing overall social well-being. The basic concept, therefore, is unchanged in the final policy, although minor changes were made to improve understanding based on the comments.

Comment: Rather than rely on strict inflexible mitigation goals, the Service should use "tradeoff" evaluation procedures in developing mitigation proposals.

Response: It is the responsibility of the Federal action agency to use tradeoff evaluation procedures consistent with the Water Resources Council's Principles and Standards, where applicable, to select a mitigation alternative that will assist in maximizing overall project benefits. The Fish and Wildlife Coordination Act specifies that "the project plan shall include such justifiable means and measures for wildlife purposes as the *reporting agency* (emphasis added) finds should be adopted to obtain maximum overall project benefits." The role of the Service is to represent those public trust resources under its jurisdiction. The proposed policy outlined a system wherein the highest valued resources would be subject to the most protective mitigation recommendations. Few, if any, commentors have disagreed with this valuation perspective. Therefore, no changes were made.

However, many commentors have questioned the reasonableness of a seemingly uncompromising system that did not appear to allow occasional deviations from these goals.

The system is not rigid. As stated in the Purpose section of the policy, the policy advice will be used as guidance for Service personnel, but variations appropriate to individual circumstances are permitted.

Comment: Numerous commentors raised the issue of the somewhat subjective nature of identifying certain species as "important" for the purposes of the policy. In addition, commentors indicated that such distinctions could lead to mis-classification of habitats in terms of resource categories and that clear criteria were needed. Finally, many commentors felt that the artificial distinction of certain species as "important" was both a violation of the public trust and Service legal authorities.

Response: People perceive some species to be more important than others. In the context of biology and ecology, all species are important, serving a useful purpose within the confines of their biological niche. The mitigation policy must address *both* the needs and desires of human society *and* the ecosystem perspective. This is a difficult task. But human decisions concerning fish and wildlife resources in the face of a development action require judgment about the values of what will be lost and the need to avoid or minimize and compensate for loss of such values.

The specific criteria for such determinations are also exceedingly difficult to frame in a National policy context. The importance of a species to society depends on a complex, changing mix of factors. The importance of a species within an ecosystem is also subject to many dynamic factors. But human decisions about the level and type of mitigation necessary for development actions must be made in the absence of perfect information concerning these factors. In addition, the Service biologist reviewing project impacts has severe constraints on the number of species and ecosystem linkages that can be analyzed given funding, personnel and time limitations. Somehow, choices must be made.

We have deleted the term "important species" from the policy and replaced it with a more precise term, "evaluation species." The criteria for selection of evaluation species still includes those species of high resource value to humans or that represent a broader ecological perspective of an area. Other changes have been made related to the determination of resource categories to allow for additional public input and resource agency coordination into such determinations, where appropriate.

The effect of this change is not intended and shall not be interpreted to broaden the scope or extent of application of this policy. But it does remove the implication that species can be ranked against each other in terms of their overall importance to society, which many considered quite beyond the capability of human beings.

Comment: The wording of the policy should clearly indicate that species selected for analysis should only be those demonstrated to actually utilize an area.

Response: We agree, except for situations where fish and wildlife restoration or improvement plans have been approved by State or Federal resource agencies. In that case the analysis will include species identified in such plans. Appropriate clarification has been added to the definition of evaluation species.

Comment: The proper focus of the policy should be the ecosystem rather than particular species.

Response: Aside from the very real technical problems of applying a complex concept such as the ecosystem to mitigation planning, the authorities underlying this policy deal with fish and wildlife and their habitat, rather than ecosystems.

Ecosystems are addressed under this policy in two ways. First, one criterion in the selection of an evaluation species is the biological importance of the species to the functioning of its ecosystem. Secondly, when habitat loss is mitigated, the part of the ecosystem comprising that habitat is itself protected. No changes have been made.

Comment: Recreational use losses may at times have to be directly mitigated. The goal statements should reflect this need.

Response: We agree. Appropriate changes were made.

Comment: In addition to assessing conditions of scarcity from a biogeographical viewpoint, i.e., ecoregions, the policy should also use geopolitical subdivisions, e.g., state boundaries.

Response: As a Federal agency, the Service perceives its major responsibility to be to protect those fish and wildlife and their habitat that are valuable and scarce on a national level, whether or not they transcend state boundaries. However, should State resource agencies wish to outline relative scarcity on a more local basis, Service personnel would certainly assist, whenever practicable. This point has been added to the policy.

Comment: The policy should scale the relative need to achieve a particular mitigation goal to the degree a particular habitat will be impacted. For example, if a half-acre of important habitat is affected by a project and it is part of a one-acre plot, this circumstance should lead to a mitigation recommendation different from the situation where the same half-acre is part of a ten thousand acre area. As drafted, the policy does not reflect the differences in these situations.

Response: The Purpose section of the policy states that it will be used as guidance for Service personnel, but variations appropriate to individual circumstances will be permitted. The relative need to achieve a particular mitigation goal depends primarily on the perceived value of the habitat, its scarcity, and the replaceability of the threatened habitat. Other factors, such as scaling considerations, can combine to modify this general Service perspective on what constitutes appropriate mitigation.

Comment: The resource categories and mitigation goals are general, lack definition, and provide no guidance on habitat value. These categories are all

subject to interpretation by the Service field personnel.

Response: It would be counterproductive, if not impossible, for a national policy to be worded as precisely as the commentor suggests and still be implemented in a reasonable manner under numerous and diverse local circumstances. Words used to describe resource categories and mitigation goals do have generally understood meanings. It is essential that field personnel be allowed to exercise professional judgment in applying resource categories and mitigation goals to specific activities. However, numerous clarifying changes were made based on the comments to increase comprehension and understanding.

Comment: It is essential to other agencies' review to know what general types of habitat will be most important in the U.S. Fish and Wildlife Service mitigation policy. At a minimum, some examples of the types of habitat within each category should be given.

Response: The final policy does give guidance on areas that will be generally considered for Resource Category 1 or 2. Providing examples for all resource categories could be misleading since the same type of habitat may fall into several different resource categories, depending on, among other factors, its relative scarcity and quality from one locale to another across the nation.

On the other hand, field professionals are generally familiar with the quality and abundance of a given type of habitat that is in their area, so it is preferable not to burden them with potentially inappropriate guidelines of this nature.

Comment: The policy should clearly distinguish between upland habitats and the more valuable wetland habitats.

Response: In some cases, upland habitats may be determined to have resource values equal to or greater than wetland habitats, so a policy that solely favored one habitat type over the other would not be in the best public interest. However, the policy has been changed to indicate that certain habitats within Service-identified Important Resource Problems (IRPs) and special aquatic sites should be given special consideration as Resource Category 1 or 2. The IRPs contain a predominance of wetland coastal areas.

Comment: If you build something in a habitat, it just changes it to another habitat that some other animal or fish lives in—including the human being, although the Service does not seem to appreciate that. For example, if you build a highway, it is bad for dogs, rabbits, opossums and field rats and such that get run over by cars and trucks, but it is good for crows and buzzards that eat dead meat.

Response: The Service has not come across many instances where crows and buzzards could be considered scarce, but when such a circumstance can be documented and verified, the Service will certainly try to protect and enhance valuable highway habitat.

- *Resource Category 1*

Comment: A literal interpretation of the Resource Category 1 mitigation goal would require absolutely no habitat loss—not even a nature trail. Resource Category 1 should be deleted.

Response: Not all environmental changes are adverse to the habitat of a fish and wildlife resource. If a nature trail resulted in an insignificant impact on habitat value that was determined not to be adverse, then the Service would not recommend against it. The policy has been clarified to reflect this point.

Comment: Endangered and threatened species should be included as part of Resource Category 1.

Response: It would be inappropriate to expand the scope of the Mitigation Policy to include threatened and endangered species. The treatment of these species is addressed in an extensive body of complex and detailed legislation and regulation. The Congress has legislated very specific and precise law with regard to threatened and endangered species. Inclusion of these species under this policy would only confuse the issue and compound the difficulties involved in implementation of the Endangered Species Act and its associated regulations. Other reasons are discussed in the scope section of the final policy.

Comment: For all practical purposes, Resource Categories 1 and 2 adopt a "no growth" policy.

Response: The U.S. Fish and Wildlife Service is not advocating a "no growth" mitigation policy. The means and measures to achieve mitigation for Resource Categories 1 and 2 are designed to provide some flexibility so that limited growth can occur in an environmentally prudent manner. The policy reflects the national consensus that some habitats are of exceptional public value and should be carefully conserved, as evidenced in the Wild and Scenic Rivers Act (Pub. L. 90–542), the Wilderness Act (Pub. L. 88–577), and the National Trails System Act (Pub. L. 94–527).

- *Resource Category 2*

Comment: It is ill-advised to support in-kind replacement involving trading habitat for lesser value habitat which is then improved to support the species affected by the project. It takes too long and in the meantime, populations supported by the habitat on the project site are lost.

Response: If the period required for improving the replacement habitat to th appropriate condition was exceedingly long, this may be one indication that the habitat at risk was unique or irreplaceable and actually belonged in Resource Category 1. In that case in-kin replacement through improvement of lesser quality habitat would be an inappropriate mitigation recommendation. Also, additional measures aimed at population restoration could be recommended to restock the area, provided suitable habitat was available to support the stocked species. No changes were made

Comment: One commenter was perturbed by an apparently rigid insistence by the policy of in-kind replacement of lost habitat. The commentor pointed out that there could be occasions in which in-kind habitat was not available to a project sponsor.

Response: The policy guideline for Resource Category 2 includes an exception when "* * * in-kind replacement is not physically or biologically attainable". No change wa necessary.

Comment: The policy appears to insis upon "acre-for-acre" replacement of in-kind habitat.

Response: The policy does not insist on "acre-for-acre" replacement of in-kind habitat. The mitigation planning goals involving in-kind replacement specifically ask for replacement of in-kind habitat *value*. This point has been further clarified in the definitions section, throughout the policy, and in th policy preamble.

- *Resource Category 3*

Comment: The mitigation goal for Resource Category 3 is not authorized by law and will be difficult to implemen due to professional disagreement on satisfactory achievement.

Response: Under the Fish and Wildli Coordination Act, the Service has the responsibility to recommend compensation for the loss of fish and wildlife resources. The Act does not restrict compensation to in-kind compensation. By recommending out-o kind compensation under certain circumstances, the Service increases th range of options that developers may use to mitigate project impacts to include development and improvemen of marginal resources different from those lost. However, modifications hav been made in the policy to indicate tha

in-kind replacement is preferred for Resource Category 3.

Comment: The mitigation goal for Resource Category 3 should emphasize that in-kind habitat value replacement is preferable to out-of-kind replacement.

Response: We agree. This point has been brought out in the final policy statement.

Comment: Although out-of-kind replacement is acceptable for Resource Category 3 losses and, under certain circumstances, may be accepted for Resource Category 2 losses, the policy should advise against replacement of rare habitat types for more common habitat types.

Response: We agree with the commentor's point and expect that Service field personnel will recommend mitigation alternatives that incorporate this concept, to the extent practicable. The Service is entirely in favor of preserving and/or promoting habitat diversity. No changes were necessary.

• *Resource Categories 4 and 5*

Comment: Compensation should be included as a means for satisfying the mitigation goal for Resource Category 4.

Response: Appropriate language changes have been made to allow for such recommendations.

Comment: Habitats encompassed by Resource Categories 4 and 5 are the only areas wherein significant increases in fish and wildlife can be realized through habitat improvement. Yet, the mitigation goals for these categories allow continual loss of these areas which possess great potential for improvements in carrying capacity.

Response: The Service appreciates the significance of areas with relatively low existing habitat values with respect to their potential for carrying capacity improvements. In fact, the Service may recommend improvement of these areas' habitat values to mitigate for unavoidable losses in Resource Categories 2 and 3. In addition, where these areas are included in a project planning area and are not appropriate for mitigation efforts, the Service will recommend that all opportunities for enhancement of these areas be thoroughly considered and included in project plans, where practicable.

We have amended the policy to include the above guidance.

Comment: Resource Category 5 is confusing and unnecessary. All habitat has some value, no matter how low. It should be redefined or deleted.

Response: We agree. This resource category has been deleted from the final policy.

C. Mitigation Planning Procedures

1. *Mitigation Goals*

Comment: Developers, Federal resource agencies, and the public should participate with the Service and State agencies in making Resource Category determinations and in developing mitigation proposals.

Response: Developers, as well as other members of the public, may provide information that will assist the Service in making Resource Category determinations. This opportunity has been noted in the final policy statement. Moreover, where these parties' inputs will significantly aid in development of mitigation proposals that will adequately satisfy mitigation planning goals, the Service will welcome their input.

Comment: It is hoped that reclassification of habitats in Resource Category 3 to Resource Categories 2 or 1 can be readily employed if and when certain habitats become more scarce.

Response: Resource Category determinations are made on the basis of conditions likely to occur without the project. If those conditions later change, the Resource Category of a given habitat can be redetermined.

However, once a mitigation plan in connection with a given project has been agreed upon, the U.S. Fish and Wildlife Service will not provide new or additional recommendations except under limited circumstances as outlined in the policy under the scope section.

2. *Impact Assessment Methods*

Comment: The policy does not appear to recognize that development activities may also show positive environmental effects. For example, cleared spaces beneath power lines can provide browsing areas for wildlife. Such positive effects should be factored into the mitigation assessment process.

Response: We agree. This point has been included in the final policy statement. The final policy further indicates that the Service and other State and Federal resource agencies shall make the determination of whether a biological change constitutes a beneficial or adverse impact. However, when determining mitigation needs for a planning area, the Service will utilize these policy guidelines to determine whether these positive effects can be applied towards mitigation.

Comment: The draft policy indicates "no net loss" as a goal for certain Resource Categories but it is unclear in defining the time period allowed to restore the land to its original value as in the case of strip mining operations. Maintenance of "no net loss" throughout the life of a long-term operation is not possible.

Response: The policy states that the net biological impact of a specific project proposal is the difference in predicted habitat value between the future with the action and the future without the action. This is based on the procedures established by the Water Resources Council's Principles and Standards. The future with the project determination includes consideration of losses during the life of the project. Under the policy, if the disturbed habitat is of sufficient value for evaluation species to warrant a Resource Category 2 or 3 level determination, the Service will provide recommendations for "no net loss" over the life of the project. The ability of the project sponsor to achieve this goal depends on many factors that cannot be predicted in advance. In many cases, it will be possible to achieve this goal. No change was necessary.

Comment: The with and without analyses should make allowances for human activities and natural species successions which can reasonably be expected to take place in the project area.

Response: We agree. Appropriate changes have been made in this policy.

Comment: Many commentors disagreed with the emphasis placed on the *Habitat Evaluation Procedures* (HEP) within the Service policy statement. Some commentors felt it should be de-emphasized, whereas others felt it deserved further emphasis.

Response: Although references to the more technical aspects of HEP have been deleted, the methodology itself remains one of the Service's more important impact assessment tools. The policy does not recommend exclusive use of HEP, since time or resource contraints may, in some cases, show alternative methods to be more practical. Where HEP habitat value assessments do not fully capture important biological characteristics within a planning area, Service personnel will use supplemental data, methodologies, and/or professional judgment to develop appropriate mitigation proposals.

Comment: What are the "other habitat evaluation systems" alluded to in the policy's section on impact assessment methods? This reference is very vague.

Response: Other systems can include the Habitat Evaluation System (HES) developed by the Department of the Army, and the Instream Flow Incremental Methodology (IFIM) of the U.S. Fish and Wildlife Service. Additional systems are referenced by the Water Resources Council in a draft document entitled, "Analysis of

Wetland Evaluation Procedures" and other publications. This information is not appropriate for inclusion into the policy so no change was made.

Comment: If other methodologies are found to be more appropriate for use than the Instream Flow Incremental Methodology (IFIM) for measuring flow impacts, they should be used.

Response: We agree. The final policy does state, however, that consideration should be given to the use of the IFIM.

Comment: Hopefully, this policy will stop the piecemeal destruction of valuable habitat, especially in areas like the Florida Keys where insidious lot-by-lot development continues in low wetland sites with the concurrence of the U.S. Fish and Wildlife Service.

Response: The Service does not concur with piecemeal development where significant resource losses will occur. Cumulative impacts are addressed by this policy. The Service is sensitive to this loss of habitat and will seek mitigation consistent with this policy. No change was necessary.

Comment: Population information should be included as an additional factor in determining mitigation requirements.

Response: We agree. Although population mitigation was an implicit part of the proposed policy, further language clarifying this point has been added to the final policy statement.

Comment: Professional judgment should be used as an alternative method for assessing project impacts.

Response: We agree that this is a valuable method that has been in use for many years. It is difficult to improve on informed and considered scientific judgment by an expert. The Service will continue to rely heavily on this approach. The policy was changed to reflect this emphasis.

3. *Mitigation Recommendations*

Comment: Service recommendations should be timely.

Response: The proposed and final policy specifically require Service personnel to present mitigation recommendations "* * * at the earliest possible stage of project planning to assure maximum consideration." This point has been echoed throughout Service management documents. Service personnel can generally provide timely guidance provided developers make a point of notifying them of proposed projects still in the planning stage and provided Federal action agencies supply sufficient transfer funding with which to conduct environmental investigations. Under Section 2(e) of the Fish and Wildlife Coordination Act, Federal action agencies are authorized to transfer funds to the Service "* * * as may be necessary to conduct all or part of the investigations required to carry out the purposes of * * * (Section 2 of the Act)." The Service uses these transfer funds to conduct project-specific investigations.

Comment: Requiring field biologists to consider cost-effectiveness in providing mitigation recommendations is beyond their capability and may conflict with the lead agencies' role as the determiner of overall public interest. Habitat protection should be a higher priority than cost-effectiveness.

Response: The proposed policy did not require a cost-effectiveness analysis by Service biologists in a formal sense. We fully agree that Service personnel must perceive their responsibility to be analysis and recommendations based on the biological aspects of project proposals. There is no intent to require Service biologists to do a formal economic analysis for which they are not trained nor for which there is clear legislative direction. However, the Service has a responsibility to the public to give consideration to cost while recommending ways to conserve fish and wildlife. The policy has been changed to reflect this need for consideration of other factors.

Comment: The Federal action agency should have the option of non-Service expertise to develop mitigation measures in those instances where the Service cannot meet lead agency program requirements.

Response: Although the Service cannot prevent other agencies from utilizing biological expertise from non-Federal sources to develop mitigation plans, the Fish and Wildlife Coordination Act specifically authorizes the Secretary of the Interior to prepare a report and recommendations on the fish and wildlife aspects of projects, including mitigation. This report and recommendations are to receive "full consideration" by the development agency. If the Federal action agency involves the Service early and provides sufficient transfer funds, then the Service should be able to meet their needs. No change in the policy was necessary.

Comment: Several mitigation proposals should be prepared for each alternative structural or non-structural plan.

Response: The Service is willing to prepare multiple proposals provided funds and time are available.

Comment: Some commentors felt that concurrent and proportionate funding of mitigation may not always lead to optimal mitigation and should not be a rigid requirement. Other commentors strongly supported concurrent and proportionate funding.

Response: The Water Resources Council's Principles and Standards require "* * * *at least* concurrent and proportionate implementation with other major project features, except where such concurrent and proportionate mitigation is physically impossible" (emphasis added).

We agree with the Council, and endorse expenditure of funds at an earlier stage of project planning when this will lead to more effective mitigation. Appropriate changes to the policy on this matter have been made.

Comment: Mitigation costs should include the cost of managing the acquired land for the life of the project, and the value of present and future timber and crops on acquired land. In addition, an environmental benefit/cost analysis should be developed for each project, and Congress should not authorize a project unless the project plan includes the proposed mitigation program and all its costs, including the cost of lost timber productivity and other resources.

Response: Costing of projects is determined by the Water Resource Council's Principles and Standards and is therefore beyond the jurisdiction of this policy. We point out that Service policy does not preclude timber harvest or other resource recovery operations on mitigation lands when the activity is compatible with fish and wildlife management objectives.

Comment: The Service mitigation policy should more clearly note that fee simple land acquisition should be a measure of last resort.

Response: The policy statement has undergone further modification to more clearly stress the conditions when land acquisition is to be recommended by Service personnel. In the future, the Service will place far greater emphasis on developing mitigation recommendations that avoid, minimize, or rectify impacts in order to reduce the need for compensation lands. Amplification of this point may be seen in the section on mitigation planning procedures.

Comment: If some interest in land must be acquired, areas of marginal productivity should be considered first. Such underdeveloped land would benefit from better management of its productive capacity and respond more vigorously than land already at higher levels of production.

Response: We agree that special consideration should be given to marginal lands, and have changed the policy accordingly.

Comment: Who owns land acquired for mitigation purposes?

Response: Depending on the individual circumstances of the project, land acquired through fee-simple title is usually owned either by the Federal or State government and administered by appropriate Federal or State resource agencies. Where wildlife easements are acquired, the land belongs to the property owner, and the easement right to the Federal or State government.

Comment: The policy should require Service personnel to identify the authority to be used in implementing any mitigation recommendations that are made.

Response: The final policy clearly identifies the legal authorities under which the Service is expected to develop mitigation recommendations. In addition, the policy only applies to Service recommendations and is not an instrument directing legal research in individual circumstances. It would be inappropriate to instruct our personnel to identify the implementing authority for the development agencies which are fully aware of the authorities available to implement Service recommendations. In the case of projects to be authorized by Congress, authorities to implement mitigation can be, and increasingly have been, spelled out.

Comment: The policy neglects to indicate the necessary process if an agency does not agree with Service mitigation recommendations.

Response: This process has already been established for most Federal agencies. If the project planners and the Service field office cannot agree on a modified or substitute proposal for mitigation, the matter often is referred upwards to the next highest level. Higher management levels are then generally able to resolve the issue quickly, although the Federal action agency has the final say. No change was necessary.

Comment: Mitigation recommendations should ensure that habitats which are preserved are adequate in size and contiguous to ensure species survival and ecosystem functioning.

Response: We agree. This point has not, however, been added to the policy since it is standard operating procedure at the field level.

Comment: Improvement of public use prospects within a project area should not be considered mitigation for habitat value losses. Development of public access is legitimate mitigation only when public uses are lost as a result of project action.

Response: We agree. Construction of public access facilities does not replace habitat lost or degraded and may even reduce wildlife habitat and invite degradation by making an area more accessible to more people. Construction of public use facilities may be in the public interest but should not be disguised as mitigation for loss or degradation of wildlife habitat. This point has been added to the policy.

4. *Follow-up*

Comment: The Service should initiate post-project evaluation studies, as well as encourage, support, and participate in these studies.

Response: We agree and will do so within the constraints of time, personnel and cost. The Service will initiate additional follow-up studies when funds are provided by the Federal action agency. The policy has been changed to reflect this.

Comment: Follow-up studies must be designed so as to separate the effects on fish and wildlife populations of implementing mitigation recommendations from other causes of changes in species numbers. This has not been the case in past studies.

Response: We agree in principle, but point out that this is a very difficult task technically, and that the conclusions in this regard rarely withstand vigorous analysis.

Nonetheless, distinguishing the true causes of population changes should be one of the goals of the follow-up study.

Comment: The policy should indicate what actions would occur if post-project evaluation shows mitigation recommendations are not being achieved as agreed to by the developer.

Response: We agree. The policy now includes provisions instructing Service personnel to recommend corrective action in such situations.

Appendix A

No significant comments.

Appendix B

Comment: Why not include more intensive management of remaining habitat as a way of reducing net habitat loss?

Response: We agree, and have modified the policy accordingly in the Means and Measures section, which has since been integrated into the body of the final policy.

The section clearly places priority on increased habitat management as a means of replacing habitat losses, and additionally stresses use of existing public lands to accomplish these ends.

Comment: A mitigation recommendation of "No project" is not logical or valid as a mitigation measure.

Response: The Council on Environmental Quality's definition of mitigation, which has been adopted in this policy, clearly states that mitigation includes ". . . avoiding the impact altogether by not taking a certain action or parts of an action. . . ." Obviously, a mitigation recommendation of "No project" falls under this subset of the definition, since a project's impact can be avoided *altogether* by a decision not to construct a project.

Appendix C

Comment: The definition of the word "practicable" should be amended to denote that the burden of identifying alternative mitigation measures and of conducting a searching inquiry into their practicability rests with the Service as well as the Federal action agency.

Response: The policy indicates that the Service will strive to provide mitigation recommendations that represent the best judgment of the Service on the most effective means and measures to achieve the mitigation goal, including consideration of cost.

Comment: A definition for "developments" (as used in Section V.A., "General Principles") should be provided in Appendix C.

Response: "Development" is a general-purpose term encompassing those activities falling under the scope of Service mitigation authorities cited within this policy. For example, if timber harvesting activities require preparation of an EIS, or involves waters of the U.S. and requires the issuance of a Federal permit or license, the Service would provide mitigation recommendations consistent with the policy.

NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The Service has prepared an Environmental Assessment of this final policy. Based on an analysis of the Environmental Assessment, the Director of the U.S. Fish and Wildlife Service has concluded that the final action is not a major Federal action which would significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act of 1969 (42 U.S.C. 4321–4347). Thus the policy does not require an Environmental Impact Statement (EIS).

The Environmental Assessment and Finding of No Significant Impact will be furnished upon request.

REGULATORY ANALYSIS

This policy statement has been issued in conformity with the Department of the Interior's rulemaking requirements, which apply to actions meeting the broad definition of a rule set forth in the Administrative Procedures Act, 5 U.S.C.

551(4) and 43 CFR Part 14.2(e) (1980). This statement is not intended to be judicially enforceable. It will not be codified. It does not create private rights. It only guides internal Service administration and is not to be inflexibly applied by Service personnel. The Department had previously determined that the proposed policy was not a significant rule and did not require a regulatory analysis under Executive Order 12044 and 43 Part 14. No significant changes were made in the final policy that required a new determination.

ACKNOWLEDGEMENTS

The primary author of this final policy is John Christian, Leader, Policy Group—Environment, U.S. Fish and Wildlife Service, (202) 343–7151. Primary support for policy development was provided by policy analysts Nancy Chu, Scott Cameron, and Peter Ciborowski; and Ecological Services Washington Office and field personnel. Manuscript preparation was accomplished by Roberta Hissey, Karen Baker, Carol Prescott, and Jinethel Baynes.

Accordingly, the mitigation policy of the U.S. Fish and Wildlife Service is set forth as follows:

U.S. FISH AND WILDLIFE SERVICE MITIGATION POLICY

I. PURPOSE

This document establishes policy for U.S. Fish and Wildlife Service recommendations on mitigating the adverse impacts of land and water developments on fish, wildlife, their habitats, and uses thereof. It will help to assure consistent and effective recommendations by outlining policy for the levels of mitigation needed and the various methods for accomplishing mitigation. It will allow Federal action agencies and private developers to anticipate Service recommendations and plan for mitigation measures early, thus avoiding delays and assuring equal consideration of fish and wildlife resources with other project features and purposes. This policy provides guidance for Service personnel but variations appropriate to individual circumstances are permitted.

This policy supersedes the December 18, 1974, policy statement entitled "Position Paper of the Fish and Wildlife Service Relative to Losses to Fish and Wildlife Habitat Caused by Federally Planned or Constructed Water Resource Developments" and the Service River Basin Studies Manual Release 2.350 entitled "General Bureau Policy on River Basin Studies."

II. AUTHORITY

This policy is established in accordance with the following major authorities: (See Appendix A for other authorities.)

Fish and Wildlife Act of 1956 (16 U.S.C. 742(a)–754). This Act authorizes the development and distribution of fish and wildlife information to the public, Congress, and the President, and the development of policies and procedures that are necessary and desirable to carry out the laws relating to fish and wildlife including: (1) ". . . take such steps as may be required for the development, advancement, management, conservation, and protection of the fisheries resources;" and (2) ". . . take such steps as may be required for the development, management, advancement, conservation, and protection of wildlife resources through research . . . and other means."

Fish and Wildlife Coordination Act (16 U.S.C. 661–667(e)). This Act authorizes the U.S. Fish and Wildlife Service, National Marine Fisheries Service (NMFS), and State agencies responsible for fish and wildlife resources to investigate all proposed Federal undertakings and non-Federal actions needing a Federal permit or license which would impound, divert, deepen, or otherwise control or modify a stream or other body of water and to make mitigation and enhancement recommendations to the involved Federal agency. "Recommendations . . . shall be as specific as practicable with respect to features recommended for wildlife conservation and development, lands to be utilized or acquired for such purposes, the results expected, and shall describe the damage to wildlife attributable to the project and the measures proposed for mitigating or compensating for these damages." In addition, the Act requires that wildlife conservation be coordinated with other features of water resource development programs.

Determinations under this authority for specific projects located in estuarine areas constitute compliance with the provisions of the Estuary Protection Act. (See Appendix A.)

Watershed Protection and Flood Prevention Act (16 U.S.C. 1001–1009). This Act allows the Secretary of the Interior to make surveys, investigations, and ". . . prepare a report with recommendations concerning the conservation and development of wildlife resources . . ." on small watershed projects.

National Environmental Policy Act of 1969 (42 U.S.C. 4321–4347). This Act and its implementing regulations (40 CFR Part 1500–1508) requires that the U.S. Fish and Wildlife Service be notified of all major Federal actions affecting fish and wildlife resources and their views and recommendations solicited. Upon completion of a draft Environmental Impact Statement, the Service is required to review it and make comments and recommendations, as appropriate. In addition, the Act provides that "the Congress authorizes and directs that, to the fullest extent possible . . . all agencies of the Federal Government shall . . . identify and develop methods and procedures . . . which will ensure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations."

III. SCOPE

A. Coverage

This policy applies to all activities of the Service related to the evaluation of impacts of land and water developments and the subsequent recommendations to mitigate those adverse impacts except as specifically excluded below. This includes: (1) investigations and recommendations for all actions requiring a federally issued permit or license that would impact waters of the U.S.; (2) all major Federal actions significantly affecting the quality of the human environment; and (3) other Federal actions for which the Service has legislative authority or executive direction for involvement including, but not limited to: coal, minerals, and outer continental shelf lease sales or Federal approval of State permit programs for the control of discharges of dredged or fill material.

B. Exclusions

This policy does not apply to threatened or endangered species. The requirements for threatened and endangered species are covered in the Endangered Species Act of 1973 and accompanying regulations at 50 CFR Parts 17, 402, and 424. Under Section 7 of the Endangered Species Act, as amended, all Federal agencies shall ensure that activities authorized, funded, or carried out by them are not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. Mitigating adverse impacts of a project would not in itself be viewed as satisfactory agency compliance with Section 7. Furthermore, it is clear to the Service that Congress considered the traditional concept of mitigation to be inappropriate for Federal activities impacting listed species or their critical habitat.

This policy does not apply to Service recommendations for Federal projects completed or other projects permitted or licensed prior to enactment of Service authorities (unless indicated otherwise in a specific statute) or specifically exempted by them and not subject to reauthorization or renewal. It also does not apply where mitigation plans have already been agreed to by the Service, except where new activities or changes in current activities would result in new impacts or where new authorities, new scientific information, or developer failure to implement agreed upon recommendations make it necessary. Service personnel involved in land and water development investigations will make a judgment as to the applicability of the policy for mitigation plans under development and not yet agreed upon as of the date of final publication of this policy.

Finally, this policy does not apply to Service recommendations related to the enhancement of fish and wildlife resources. Recommendations for measures which improve fish and wildlife resources beyond that which would exist without the project and which cannot be used to satisfy the

appropriate mitigation planning goal should be considered as enhancement measures. The Service strongly supports enhancement of fish and wildlife resources. The Service will recommend that all opportunities for fish and wildlife resource enhancement be thoroughly considered and included in project plans, to the extent practicable.

IV. DEFINITION OF MITIGATION

The President's Council on Environmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations to include: "(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments." (40 CFR Part 1508.20(a–e)).

The Service supports and adopts this definition of mitigation and considers the specific elements to represent the desirable sequence of steps in the mitigation planning process. (See Appendix B for definitions of other important terms necessary to understand this policy.)

V. MITIGATION POLICY OF THE U.S. FISH AND WILDLIFE SERVICE

The overall goals and objectives of the Service are outlined in the Service Management Plan and an accompanying Important Resource Problems document which describes specific fish and wildlife problems of importance for planning purposes. Goals and objectives for Service activities related to land and water development are contained in the Habitat Preservation Program Management Document. The mitigation policy was designed to stand on its own; however, these documents will be consulted by Service personnel to provide the proper perspective for the Service mitigation policy. They are available upon request from the Director, U.S. Fish and Wildlife Service, Washington, D.C. 20240.

A. General Policy

The mission of the U.S. Fish and Wildlife Service is to:

PROVIDE THE FEDERAL LEADERSHIP TO CONSERVE, PROTECT AND ENHANCE FISH AND WILDLIFE AND THEIR HABITATS FOR THE CONTINUING BENEFIT OF THE PEOPLE.

The goal of Service activities oriented toward land and water development responds to Congressional direction that fish and wildlife resource conservation receive equal consideration and be coordinated with other features of Federal resource development and regulatory programs through effective and harmonious planning, development, maintenance and coordination of fish and wildlife resource conservation and rehabilitation in the United States, its territories and possessions. The goal is to:

CONSERVE, PROTECT AND ENHANCE FISH AND WILDLIFE AND THEIR HABITATS AND FACILITATE BALANCED DEVELOPMENT OF THIS NATION'S NATURAL RESOURCES BY TIMELY AND EFFECTIVE PROVISION OF FISH AND WILDLIFE INFORMATION AND RECOMMENDATIONS.

Fish and wildlife and their habitats are public resources with clear commercial, recreational, social, and ecological value to the Nation. They are conserved and managed for the people by State, Federal and Indian tribal Governments. If land or water developments are proposed which may reduce or eliminate the public benefits that are provided by such natural resources, then State and Federal resource agencies and Indian tribal agencies have a responsibility to recommend means and measures to mitigate such losses. Accordingly:

IN THE INTEREST OF SERVING THE PUBLIC, IT IS THE POLICY OF THE U.S. FISH AND WILDLIFE SERVICE TO SEEK TO MITIGATE LOSSES OF FISH, WILDLIFE, THEIR HABITATS, AND USES THEREOF FROM LAND AND WATER DEVELOPMENTS.

In administering this policy, the Service will strive to provide information and recommendations that fully support the Nation's need for fish and wildlife resource conservation as well as sound economic and social development through balanced multiple use of the Nation's natural resources. The Service will actively seek to facilitate needed development and avoid conflicts and delays through early involvement in land and water development planning activities in advance of proposals for specific projects or during the early planning and design stage of specific projects.

This should include early identification of resource areas containing high and low habitat values for important species and the development of ecological design information that outlines specific practicable means and measures for avoiding or minimizing impacts. The former can be used by developers to site projects in the least valuable areas. This could possibly lower total project costs to development interests. These actions are part of good planning and are in the best public interest.

The early provision of information to private and public agencies in a form which enables them to avoid or minimize fish and wildlife losses as a part of initial project design is the preferred form of fish and wildlife conservation.

B. U.S. Fish and Wildlife Service Mitigation Planning Goals by Resource Category

The planning goals and guidelines that follow will be used to guide Service recommendations on mitigation of project impacts. Four Resource Categories are used to indicate that the level of mitigation recommended will be consistent with the fish and wildlife resource values involved.

The policy covers impacts to fish and wildlife populations, their habitat and the human uses thereof. However, the primary focus in terms of specific guidance is on recommendations related to habitat value losses. In many cases, compensation of habitat value losses should result in replacement of fish and wildlife populations and human uses. But where it does not, the Service will recommend appropriate additional means and measures.

RESOURCE CATEGORY 1

a. Designation Criteria

Habitat to be impacted is of high value for evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section.

b. Mitigation Goal

No Loss of Existing Habitat Value.

c. Guideline

The Service will recommend that all losses of existing habitat be prevented as these one-of-a-kind areas cannot be replaced. Insignificant changes that do not result in adverse impacts on habitat value may be acceptable provided they will have no significant cumulative impact.

RESOURCE CATEGORY 2

a. Designation Criteria

Habitat to be impacted is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.

b. Mitigation Goal

No Net Loss of In-Kind Habitat Value.

c. Guideline

The Service will recommend ways to avoid or minimize losses. If losses are likely to occur, then the Service will recommend ways to immediately rectify them or reduce or eliminate them over time. If losses remain likely to occur, then the Service will recommend that those losses be compensated by replacement of the same kind of habitat value so that the total loss of such in-kind habitat value will be eliminated.

Specific ways to achieve this planning goal include: (1) physical modification of replacement habitat to convert it to the same type lost; (2) restoration or rehabilitation of previously altered habitat; (3) increased management of similar replacement habitat so that the in-kind value of the lost habitat is replaced, or (4) a combination of these measures. By replacing habitat value losses with similar habitat values, populations of species associated with that habitat may remain relatively stable in the area over time. This is generally referred to as in-kind replacement.

Exceptions: An exception can be made to this planning goal when: (1) different habitats and species available for replacement are determined to be of greater value than those lost, *or* (2) in-kind replacement is not physically or biologically attainable in the ecoregion section. In either case, replacement involving different habitat kinds may be recommended provided that the total value of the habitat lost is recommended for replacement (see the guideline for Category 3 mitigation below).

RESOURCE CATEGORY 3

a. Designation Criteria

Habitat to be impacted is of high to medium value for evaluation species and is relatively abundant on a national basis.

b. Mitigation Goal

No Net Loss of Habitat Value While Minimizing Loss of In-Kind Habitat Value.

c. Guideline

The Service will recommend ways to avoid or minimize losses. If losses are likely to occur, then the Service will recommend ways to immediately rectify them or reduce or eliminate them over time. If losses remain likely to occur, then the Service will recommend that those losses be compensated by replacement of habitat value so that the total loss of habitat value will be eliminated.

It is preferable, in most cases, to recommend ways to replace such habitat value losses in-kind. However, if the Service determines that in-kind replacement is not desirable or possible, then other specific ways to achieve this planning goal include: (1) substituting different kinds of habitats, or (2) increasing management of different replacement habitats so that the value of the lost habitat is replaced. By replacing habitat value losses with different habitats or increasing management of different habitats, populations of species will be different, depending on the ecological attributes of the replacement habitat. This will result in no net loss of total habitat value, but may result in significant differences in fish and wildlife populations. This is generally referred to as out-of-kind replacement.

RESOURCE CATEGORY 4

a. Designation Criteria

Habitat to be impacted is of medium to low value for evaluation species.

b. Mitigation Goal

Minimize Loss of Habitat Value.

c. Guideline

The Service will recommend ways to avoid or minimize losses. If losses are likely to occur, then the Service will recommend ways to immediately rectify them or reduce or eliminate them over time. If losses remain likely to occur, then the Service may make a recommendation for compensation, depending on the significance of the potential loss.

However, because these areas possess relatively low habitat values, they will likely exhibit the greatest potential for significant habitat value improvements. Service personnel will fully investigate these areas' potential for improvement, since they could be used to mitigate Resource Category 2 and 3 losses.

C. Mitigation Planning Policies

1. State-Federal Partnership

a. The U.S. Fish and Wildlife Service will fully coordinate activities with those State agencies responsible for fish and wildlife resources, the National Marine Fisheries Service (NMFS) and the Environmental Protection Agency (EPA) related to the investigation of project proposals and development of mitigation recommendations for resources of concern to the State, NMFS or EPA.

b. Service personnel will place special emphasis on working with State agencies responsible for fish and wildlife resources, NMFS and EPA to develop compatible approaches and to avoid duplication of efforts.

2. Resource Category Determinations

a. The Service will make Resource Category determinations as part of the mitigation planning process. Such determinations will be made early in the planning process and transmitted to the Federal action agency or private developer to aid them in their project planning, to the extent practicable.

b. Resource Category determinations will be made through consultation and coordination with State agencies responsible for fish and wildlife resources and other Federal resource agencies, particularly the National Marine Fisheries Service and the Environmental Protection Agency, whenever resources of concern to those groups are involved. Where other elements of the public, including development groups, have information that can assist in making such determinations, the Service will welcome such information.

c. All Resource Category determinations will contain a technical rationale consistent with the designation criteria. The rationale will: (1) outline the reasons why the evaluation species were selected; (2) discuss the value of the habitat to the evaluation species; and (3) discuss and contrast the relative scarcity of the fish and wildlife resource on a national and ecoregion section basis.

Note.—If the State agency responsible for fish and wildlife resources wishes to outline scarcity on a more local basis, U.S. Fish and Wildlife Service personnel should assist in developing such rationale, whenever practicable.

d. When funding, personnel, and available information make it practicable, specific geographic areas or, alternatively, specific habitat types that comprise a given Resource Category should be designated in advance of development. Priority for predesignation will be placed on those areas that are of high value for evaluation species and are subject to development pressure in the near future. Such predesignations can be used by developers or regulators to determine the least valuable areas for use in project planning and siting considerations.

e. The following examples should be given special consideration as either Resource Category 1 or 2:

(1) Certain habitats within Service-identified Important Resource Problem (IRP) areas. Those IRPs dealing with threatened or endangered species are not covered by this policy. (See Scope)

(2) Special aquatic and terrestrial sites including legally designated or set-aside

areas such as sanctuaries, fish and wildlife management areas, hatcheries, and refuges, and other aquatic sites such as floodplains, wetlands, mudflats, vegetated shallows, coral reefs, riffles and pools, and springs and seeps.

3. Impact Assessment Principles

a. Changes in fish and wildlife productivity or ecosystem structure and function may not result in a biologically adverse impact. The determination as to whether a biological change constitutes an adverse impact for which mitigation should be recommended is the responsibility of the Service and other involved Federal and State resource agencies.

b. The net biological impact of a development proposal (or alternatives) is the difference in predicted biological conditions between the future with the action and the future without the action. If the future without the action cannot be reasonably predicted and documented by the project sponsor, then the Service analysis should be based on biological conditions that would be expected to exist over the planning period due to natural species succession or implementation of approved restoration/improvement plans or conditions which currently exist in the planning area.

c. Service review of project impacts will consider, whenever practicable:

(1) The total long-term biological impact of the project, including any secondary or indirect impacts regardless of location; and (2) any cumulative effects when viewed in the context of existing or anticipated projects.

d. The *Habitat Evaluation Procedures* will be used by the Service as a basic tool for evaluating project impacts and as a basis for formulating subsequent recommendations for mitigation subject to the exemptions in the Ecological Services Manual (100 ESM 1). When the *Habitat Evaluation Procedures* do not apply, then other evaluation systems may be used provided such use conforms with policies provided herein.

e. In those cases where instream flows are an important determinant of habitat value, consideration should be given to the use of the Service's Instream Flow Incremental Methodology to develop instream flow mitigation recommendations, where appropriate.

f. Where specific impact evaluation methods or mitigation technologies are not available, Service employees shall continue to apply their best professional judgment to develop mitigation recommendations.

4. Mitigation Recommendations

a. The Service may recommend support of projects or other proposals when the following criteria are met:

(1) They are ecologically sound;

(2) The least environmentally damaging reasonable alternative is selected;

(3) Every reasonable effort is made to avoid or minimize damage or loss of fish and wildlife resources and uses;

(4) All important recommended means and measures have been adopted with guaranteed implementation to satisfactorily compensate for unavoidable damage or loss consistent with the appropriate mitigation goal; and

(5) For wetlands and shallow water habitats, the proposed activity is clearly water dependent and there is a demonstrated public need.

The Service may recommend the "no project" alternative for those projects or other proposals that do not meet all of the above criteria and where there is likely to be a significant fish and wildlife resource loss.

b. Recommendations will be presented by the Service at the earliest possible stage of project planning to assure maximum consideration. The Service will strive to provide mitigation recommendations that represent the best judgment of the Service, including consideration of cost, on the most effective means and measures of satisfactorily achieving the mitigation planning goal. Such recommendations will be developed in cooperation with the Federal action agency or private developer responsible for the project, whenever practicable, and will place heavy reliance on cost estimates provided by that Federal action agency or private developer.

c. The Service will recommend that the Federal action agency include designated funds for all fish and wildlife resource mitigation (including, but not limited to, Service investigation costs, initial development costs and continuing operation, maintenance, replacement, and administrative costs) as part of the initial and any alternative project plans and that mitigation funds (as authorized and appropriated by Congress for Federal projects) be spent concurrently and proportionately with overall project construction and operation funds throughout the life of the project.

Note.—Prevention of losses may necessitate expenditure of funds at an earlier stage of project planning. This is acceptable and preferred.

d. Service mitigation recommendations will be made under an explicit expectation that these means and measures: (1) would be the ultimate responsibility of the appropriate Federal action agency to implement or enforce; and (2) would provide for a duration of effectiveness for the life of the project plus such additional time required for the adverse effects of an abandoned project to cease to occur.

e. Land acquisition in fee title for the purpose of compensation will be recommended by the Service *only* under one or more of the following three conditions:

(1) When a change in ownership is necessary to guarantee the future conservation of the fish and wildlife resource consistent with the mitigation goal for the specific project area; *or*

(2) When other means and measures for mitigation (see Section 5 below) will not compensate habitat losses consistent with the mitigation goal for the specific project area; *or*

(3) When land acquisition in fee title is the most cost-effective means that may partially or completely achieve the mitigation goal for the specific project area.

Service recommendations for fee title land acquisition will seek to identify mitigation lands with marginal economic potential.

f. First priority will be given to recommendation of a mitigation site within the planning area. Second priority will be given to recommendation of a mitigation site in proximity to the planning area within the same ecoregion section. Third priority will be given to recommendation of a mitigation site elsewhere within the same ecoregion section.

g. Service personnel will fully support a variety of uses on mitigation lands where such uses are compatible with dominant fish and wildlife uses and, for Federal wildlife refuges, are consistent with the provisions of the Refuge Recreation Act and the National Wildlife Refuge Administration Act. However, it may be in the best public interest to recommend limiting certain uses that would significantly decrease habitat value for species of high public interest. In such cases, the Service may recommend against such incompatible uses.

h. Measures to increase recreation values will not be recommended by Service personnel to compensate for losses of habitat value. Recreation use losses not restored through habitat valu mitigation will be addressed through separate and distinct recommended measures to offset those specific losses.

i. The guidelines contained in this policy do not apply to threatened or endangered species. However, where both habitat and endangered or threatened species impacts are involve

Service personnel shall fully coordinate Environment efforts with Endangered Species efforts to provide timely, consistent, and unified recommendations for resolution of fish and wildlife impacts, to the extent possible. More specifically, Environment and Endangered Species personnel shall coordinate all related activities dealing with investigations of land and water developments. This includes full use of all provisions that can expedite Service achievement of "one-stop shopping," including coordinated early planning involvement, shared permit review activities, consolidated permit reporting, and consolidated flow of pre-project information to developers, consistent with legislative mandates and deadlines.

j. The Service will place high priority on and continue to develop and implement procedures for reducing delays and conflicts in permit related activities. Such procedures will include, but not be limited to:

(1) Joint processing of permits.

(2) Resource mapping.

(3) Early provision of ecological design information.

(4) Involvement in Special Area Management Planning.

k. The Service will encourage predevelopment compensation actions by Federal action agencies which can be used to offset future unavoidable losses for lands or waters not adequately protected by an existing law, policy, or program.

Banking of habitat value for the express purpose of compensation for unavoidable future losses will be considered to be a mitigation measure and not an enhancement measure. Withdrawals from the mitigation "bank" to offset future unavoidable losses will be based on habitat value replacement, not acreage or cost for land purchase and management.

5. Mitigation Means and Measures

Mitigation recommendations can include, but are not limited to, the types of actions presented below. These means and measures are presented in the general order and priority in which they should be recommended by Service personnel with the exception of the "no project" alternative. (See Section 4(a)).

a. Avoid the impact

(1) Design project to avoid damage or loss of fish and wildlife resources including management practices such as timing of activities or structural features such as multiple outlets, passage or avoidance structures and water pollution control facilities.

(2) Use of nonstructural alternative to proposed project.

(3) No project.

b. Minimize the impact

(1) Include conservation of fish and wildlife as an authorized purpose of Federal projects.

(2) Locate at the least environmentally damaging site.

(3) Reduce the size of the project.

(4) Schedule timing and control of initial construction operations and subsequent operation and maintenance to minimize disruption of biological community structure and function.

(5) Selective tree clearing or other habitat manipulation.

(6) Control water pollution through best management practices.

(7) Time and control flow diversions and releases.

(8) Maintain public access.

(9) Control public access for recreational or commercial purposes.

(10) Control domestic livestock use.

c. Rectify the impact

(1) Regrade disturbed areas to contours which provide optimal fish and wildlife habitat or approximate original contours.

(2) Seed, fertilize and treat areas as necessary to restore fish and wildlife resources.

(3) Plant shrubs and trees and other vegetation to speed recovery.

(4) Control polluted spoil areas.

(5) Restock fish and wildlife resources in repaired areas. Fish stocking or introductions will be consistent with the Service Fish Health Policy (January 3, 1978).

d. Reduce or eliminate the impact over time

(1) Provide periodic monitoring of mitigation features to assure continuous operation.

(2) Assure proper training of project personnel in the operations of the facility to preserve existing or restored fish and wildlife resources at project sites.

(3) Maintain or replace equipment or structures so that future loss of fish and wildlife resources due to equipment or structure failure does not occur.

e. Compensate for impacts

(1) Conduct wildlife management activities to increase habitat values of existing areas, with project lands and nearby public lands receiving priority.

(2) Conduct habitat construction activities to fully restore or rehabilitate previously altered habitat or modify existing habitat suited to evaluation species for the purpose of completely offsetting habitat value losses.

(3) Build fishery propagation facilities.

(4) Arrange legislative set-aside or protective designation for public lands.

(5) Provide buffer zones.

(6) Lease habitat.

(7) Acquire wildlife easements.

(8) Acquire water rights.

(9) Acquire land in fee title.

6. Follow-up

The Service encourages, supports, and will initiate, whenever practicable, post-project evaluations to determine the effectiveness of recommendations in achieving the mitigation planning goal. The Service will initiate additional follow-up studies when funds are provided by the Federal action agency.

In those instances where Service personnel determine that Federal agencies or private developers have not carried out those agreed upon mitigation means and measures, then the Service will request the responsible Federal action agency to initiate corrective action.

APPENDIX A—OTHER AUTHORITIES AND DIRECTION FOR SERVICE MITIGATION RECOMMENDATIONS

LEGISLATIVE

Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 et seq.). The 1977 amendments require the Fish and Wildlife Service ". . . upon request of the Governor of a State, and without reimbursement, to provide technical assistance to such State in developing a Statewide (water quality planning) program and in implementing such program after its approval." In addition, this Act requires the Service to comment on proposed State permit programs for the control of discharges of dredged or fill material and to comment on all Federal permits within 90 days of receipt.

Federal Power Act of 1920, as amended (16 U.S.C. 791(a), 803, 811). This Act authorizes the Secretary of the Interior to impose conditions on licenses issued for hydroelectric projects within specific withdrawn public lands. The Secretary is given specific authority to prescribe fishways to be constructed, maintained, and operated at the licensee's expense.

Estuary Protection Act (16 U.S.C. 1221–1226). This Act requires the Secretary of the Interior to review all project plans and reports for land and water resource development affecting estuaries and to make recommendations for conservation, protection, and enhancement.

Coastal Zone Management Act of 1972 (16 U.S.C. 1451–1464). This Act

requires the Secretary of Commerce to obtain the views of Federal agencies affected by the program, including the Department of the Interior, and to ensure that these views have been given adequate consideration before approval of Coastal Zone Management Plans. The Service provides the Department's views about fish and wildlife resources. Pursuant to the Coastal Zone Management Act Amendments of 1980 (Pub. L. 96–464) the Department of Interior provides comments on Federal grants to help States protect and preserve coastal areas because of their ". . . conservational, recreational, ecological or aesthetic values." The 1980 Amendments also authorize the Department of Interior to enter into Special Area Management Planning to ". . . provide for increased specificity in protecting natural resources, reasonable coast dependent economic growth . . . and improved predictability in government decisionmaking."

Water Bank Act (16 U.S.C. 1301–1311). This Act requires that the Secretary of Agriculture ". . . shall consult with the Secretary of Interior and take appropriate measures to insure that the program carried out . . . is in harmony with wetlands programs administered by the Secretary of the Interior."

Wild and Scenic Rivers Act (16 U.S.C. 1271–1287). This Act requires the Secretary of the Interior to comment on such proposals. The Fish and Wildlife Service provides the Department's views with regard to fish and wildlife resources.

Geothermal Steam Act of 1970 (30 U.S.C. 1001–1025). This Act requires that the Fish and Wildlife Service recommend to the Secretary those lands that shall not be leased for geothermal development by reason of their status as ". . . a fish hatchery administered by the Secretary, wildlife refuge, wildlife range, game range, wildlife management area, waterfowl production area, or for lands acquired or reserved for the protection and conservation of fish and wildlife that are threatened with extinction."

Surface Mining Control and Reclamation Act of 1977 (30 U.S.C. 1201 et seq.). This Act requires the Department of the Interior to regulate surface mining and reclamation at existing and future mining areas. The Fish and Wildlife Service provides the Department with technical assistance regarding fish and wildlife aspects of Department programs on active and abandoned mine lands, including review of State regulatory submissions and mining plans, and comments on mining and reclamation plans.

Outer Continental Shelf Lands Act Amendments of 1978 (43 U.S.C. 1801). This Act requires the Secretary of the Interior to manage an environmentally sound oil and natural gas development program on the outer continental shelf. The Fish and Wildlife Service provides recommendations for the Department regarding potential ecological impacts before leasing in specific areas and contributes to environmental studies undertaken subsequent to leasing.

Mineral Leasing Act of 1920, as amended (30 U.S.C. 185). This Act authorizes the Secretary of the Interior to grant rights-of-way through Federal lands for pipelines transporting oil, natural gas, synthetic liquids or gaseous fuels, or any other refined liquid fuel. Prior to granting a right-of-way for a project which may have a significant impact on the environment, the Secretary is required by this Act to request and review the applicant's plan for construction, operation, and rehabilitation of the right-of-way. Also, the Secretary is authorized to issue guidelines and impose stipulations for such projects which shall include, but not be limited to, ". . . requirements for restoration, revegetation and curtailment or erosion of surface land; . . . requirements designed to control or prevent damage to the environment (including damage to fish and wildlife habitat); and . . . requirements to protect the interests of individuals living in the general area of the right-of-way or permit who rely on the fish, wildlife and biotic resources of the area for subsistence purposes."

Cooperative Unit Act (16 U.S.C. 753(a)–753(b)). This Act provides for cooperative programs for research and training between the Fish and Wildlife Service, the States, and universities.

Airport and Airway Development Act (49 U.S.C. 1716). This Act requires the Secretary of Transportation to ". . . consult with the Secretary of the Interior with regard to the effect that any project . . . may have on natural resources including, but not limited to, fish and wildlife, natural, scenic, and recreation assets, water and air quality, and other factors affecting the environment . . .".

Department of Transportation Act (49 U.S.C. 1653(f)). This Act makes it national policy that ". . . special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites . . .," and requires that the Secretary of Transportation ". . . cooperate and consult with the Secretary of the Interior in developing transportation plans and programs that include measures to maintain or enhance the natural beauty of the lands traversed." The Department of Transportation projects using protected lands cannot be approved unless there are no feasible and prudent alternatives to avoid such use and, if none, all possible measures to minimize harm have been considered.

EXECUTIVE

President's Water Policy Message (June 6, 1978). This Message directs the Secretary of the Interior to promulgate procedures for determination of measures to mitigate losses of fish and wildlife resources.

Water Resources Council's *Final Rules; Principles and Standards for Water and Related Land Resources Planning—Level C* (September 29, 1980). These rules reiterate the importance of participation in the development planning process by interested Federal agencies, including the Department of the Interior. This participation includes review, coordination, or consultation required under various legislative and executive authorities. Under these rules, "Consideration is to be given to mitigation (as defined in 40 CFR 1508.20) of the adverse effects of each alternative plan. Appropriate mitigation is to be included where suitable as determined by the agency decisionmaker. Mitigation measures included are to be planned for at least concurrent and proportionate implementation with other major project features, except where such concurrent and proportionate mitigation is physically impossible. In the latter case, the reasons for deviation from this rule are to be presented in the planning report, and mitigation is to be planned for the earliest possible implementation. Mitigation for fish and wildlife and their habitat is to be planned in coordination with Federal and State fish and wildlife agencies in accordance with the Fish and Wildlife Coordination Act of 1958 (16 U.S.C. 661–664) (sic)."

Executive Order 11990—Protection of Wetlands (May 24, 1977). This Executive Order requires that each Federal agency ". . . take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for: (1) acquiring, managing and disposing of Federal lands and facilities; and (2) providing federally undertaken, financed or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation and licensing activities." Relevant wetland concerns and values include, but are not

limited to, maintenance of natural systems and long-term productivity of existing flora and fauna, habitat diversity, hydrological utility, fish, wildlife, timber, and food. Under this Order, a developmental project in a wetland may proceed only if no practicable alternatives can be ascertained and if the proposal . . . includes all practicable measures to minimize harm to the wetland that may result from its use."

Executive Order 11988—Floodplain Management (May 24, 1977). This Executive Order requires that Federal agencies take floodplain management into account when formulating or evaluating water or land use plans and that these concerns be reflected in the budgets, procedures, and regulations of the various agencies. This Order allows developmental activities to proceed in floodplain areas only when the relevant agencies have ". . . considered alternatives to avoid adverse effects and incompatible development in the floodplains . . ." or when, in lieu of this, they have ". . . designed or modified their actions in order to minimize potential harm to or within the floodplain . . .".

Executive Order 11987—Exotic Organisms (May 24, 1977). This Executive Order requires that Federal agencies shall restrict, to the extent permitted by law, the introduction of exotic species into the lands or waters which they own, lease, or hold for purposes of administration, and encourage the States, local governments, and private citizens to do the same. This Executive Order also requires Federal agencies to restrict, to the extent permitted by law, the importation of exotic species and to restrict the use of Federal funds and programs for such importation. The Secretary of the Interior, in consultation with the Secretary of Agriculture, is authorized to develop by rule or regulation a system to standardize and simplify the requirements and procedures appropriate for implementing this Order.

NATIONAL/INTERNATIONAL TREATIES

Federal Trust Responsibility to Indian Tribes. This responsibility is reflected in the numerous Federal treaties with the Indian tribes. These treaties have the force of law. Protection of Indian hunting and fishing rights necessitates conservation of fish and wildlife and their habitat.

Convention Between the United States and Japan (September 19, 1974). This Treaty endorses the establishment of sanctuaries and fixes preservation and enhancement of migratory bird habitat as a major goal of the signatories.

Convention Between the United States and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environments (November 8, 1978). This Treaty endorses the establishment of sanctuaries, refuges, and protected areas. It mandates reducing or eliminating damage to all migratory birds. Furthermore, it provides for designation of special areas for migratory bird breeding, wintering, feeding, and molting, and commits the signatories to ". . . undertake measures necessary to protect the ecosystems in these areas . . . against pollution, detrimental alteration and other environmental degradation." Implementing legislation, Pub. L. 95–616, was passed in the United States in 1978.

Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (April 15, 1941). This Treaty has several provisions requiring parties to conserve certain wildlife resources and their habitats.

Convention Between the United States and Great Britain (for Canada) for Protection of Migratory Birds (August 1, 1916, as amended January 30, 1979). This Treaty provides for a uniform ". . . system of protection for certain species of birds which migrate between the United States and Canada, in order to assure the preservation of species either harmless or beneficial to man." The Treaty prohibits hunting insectivorous birds, but allows killing of birds under permit when injurious to agriculture. The 1979 amendment allows subsistence hunting of waterfowl outside of the normal hunting season.

APPENDIX B—OTHER DEFINITIONS

"Compensation," when used in the context of Service mitigation recommendations, means full replacement of project-induced losses to fish and wildlife resources, provided such full replacement has been judged by the Service to be consistent with the appropriate mitigation planning goal.

"Ecoregion" refers to a large biogeographical unit characterized by distinctive biotic and abiotic relationships. An ecoregion may be subclassified into domains, divisions, provinces, and sections. A technical explanation and map is provided in the "Ecoregions of the United States" by Robert G. Bailey, published by the U.S. Forest Service, 1976.

"Ecosystem" means all of the biotic elements (i.e., species, populations, and communities) and abiotic elements (i.e., land, air, water, energy) interacting in a given geographic area so that a flow of energy leads to a *clearly* defined trophic structure, biotic diversity, and material cycles. (Eugene P. Odum. 1971. *Fundamentals of Ecology)*

"Evaluation species" means those fish and wildlife resources in the planning area that are selected for impact analysis. They must currently be present or known to occur in the planning area during at least one stage of their life history except where species not present (1) have been identified in fish and wildlife restoration or improvement plans approved by State or Federal resource agencies, or (2) will result from natural species succession over the life of the project. In these cases, the analysis may include such identified species not currently in the planning area.

There are two basic approaches to the selection of evaluation species: (1) selection of species with high public interest, economic value or both; and (2) selection of species to provide a broader ecological perspective of an area. The choice of one approach in lieu of the other may result in a completely different outcome in the analysis of a proposed land or water development. Therefore, the objectives of the study should be clearly defined before species selection is initiated. If the objectives of a study are to base a decision on potential impacts to an entire ecological community, such as a unique wetland, then a more ecologically based approach is desirable. If, however, a land or water use decision is to be based on potential impacts to a public use area, then species selection should favor animals with significant human use values. In actual practice, species should be selected to represent social, economic and broad ecological views because mitigation planning efforts incorporate objectives that have social, economic, and ecological aspects. Species selection always should be approached in a manner that will optimize contributions to the stated objectives of the mitigation planning effort.

Most land and water development decisions are strongly influenced by the perceived impacts of the proposed action on human use. Since economically or socially important species have clearly defined linkages to human use, they should be included as evaluation species in all appropriate land and water studies. As a guideline, the following types of species should be considered:

- Species that are associated with Important Resource Problems as designated by the Director of the Fish and Wildlife Service (except for threatened or endangered species).

• Other species with monetary and non-monetary benefits to people accruing from consumptive and nonconsumptive human uses including, but not limited to, fishing, hunting, bird-watching and educational, aesthetic, scientific or subsistence uses.

An analysis based only on those species with directly identifiable economic or social value may not be broad enough to adequately describe all of the ramifications of a land and water use proposal. If it is desirable to increase the ecological perspective of an assessment, the following types of species should be considered:

• Species known to be sensitive to specific land and water use actions. The species selected with this approach serve as "early warning" or indicator species for the affected fish and wildlife community.

• Species that perform a key role in a community because of their role in nutrient cycling or energy flows. These species also serve as indicators for a large segment of the fish and wildlife community, but may be difficult to identify.

• Species that represent groups of species which utilize a common environmental resource (guilds). A representative species is selected from each guild and predicted environmental impacts for the selected species are extended with some degree of confidence to other guild members.

"Federal action agency" means a department, agency or instrumentality of the United States which plans, constructs, operates or maintains a project, or which plans for or approves a permit, lease, or license for projects or manages Federal lands.

"Fish and wildlife resources" means birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent.

"Habitat" means the area which provides direct support for a given species, population, or community. It includes all environmental features that comprise an area such as air quality, water quality, vegetation and soil characteristics and water supply (including both surface and groundwater).

"Habitat value" means the suitability of an area to support a given evaluation species.

"Important Resource Problem" means a clearly defined problem with a single important population or a community of similar species in a given geographic area as defined by the Director of the Fish and Wildlife Service.

"In-kind replacement" means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost.

"Loss" means a change in fish and wildlife resources due to human activities that is considered adverse and:

(1) reduces the biological value of that habitat for evaluation species;

(2) reduces population numbers of evaluation species;

(3) increases population numbers of "nuisance" species;

(4) reduces the human use of those fish and wildlife resources; or

(5) disrupts ecosystem structure and function.

Changes that improve the value of existing habitat for evaluation species are not to be considered losses, i.e., burning or selective tree harvesting for wildlife management purposes. In addition, reductions in animal populations for the purpose of harvest or fish and wildlife managment will not be considered as losses for the purpose of this policy.

"Minimize" means to reduce to the smallest practicable amount or degree.

"Mitigation banking" means habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable losses from specific future development actions. It only includes those actions above and beyond those typically taken by Congress for protection of fish and wildlife resources.

"Out-of-kind replacement" means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically or biologically different from those lost.

"Planning area" means a geographic space with an identified boundary that includes:

(1) The area identified in the study's authorizing document;

(2) The locations of resources included in the study's identified problems and opportunities;

(3) The locations of alternative plans, often called "project areas;" and

(4) The locations of resources that would be directly, indirectly, or cumulatively affected by alternative plans, often called the "affected area."

"Practicable" means capable of being done within existing constraints. The test of what is practicable depends upon the situation and includes consideration of the pertinent factors, such as environment, cost, or technology.

"Project" means any action, planning or approval process relating to an action that will directly or indirectly affect fish and wildlife resources.

"Replacement" means the substitution or offsetting of fish and wildlife resource losses with resources considered to be of equivalent biological value. However, resources used for replacement represent loss or modification of another type of habitat value. Replacement actions still result in a loss of habitat acreage and types which will continually diminish the overall national resource base. It should be clearly understood that replacement actions never restore the lost fish and wildlife resource—that is lost forever.

Dated: January 13, 1981.

Cecil Andrus,

Secretary of the Department of the Interior.

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BILLING CODE 4310-55-M

APPENDIX 2

Summary of Habitat Evaluation Methods (including HEP and others)

One of the most difficult problems facing resource managers is the assessment of biological resources. The need for a methodology that provides both quantitative inventories of baseline conditions as well as quantitative assessments of projected environmental impacts has been recognized for many years. Although many different methodologies have been proposed, most recent methods have revolved around the value of the affected habitat. The most widely used habitat evaluation method is the Habitat Evaluation Procedures (HEP), developed by the U.S. Fish and Wildlife Service in the early 1970's. The Procedures were developed to fulfill a number of objectives (Schamberger and Farmer 1978):

1. To develop methodologies to quantitatively assess baseline habitat conditions for fish and wildlife in nonmonetary terms;
2. To provide a uniform system for predicting impacts on fish and wildlife resources;
3. To display and compare the beneficial and adverse impacts of project alternatives on fish and wildlife resources;
4. To provide a basis for recommending project alterations to compensate for or mitigate adverse effects on fish and wildlife resources; and
5. To provide data to decision makers and the public from which sound resource decisions can be made.

Objectives 3 and 4 indicate the desire of FWS to have HEP play a useful role in mitigation decisions. In particular, HEP is designed to help with one of the most problematic aspects of mitigation planning, the determination of compensation requirements.

The goal of a HEP analysis is to develop a unit of measurement by which various habitat states can be compared. These units are called Habitat Units (HU). The first step in deriving the HU's is to compute a Habitat Suitability Index (HSI), which documents the habitat quality for the species or group of species selected for evaluation. This index value is derived from an evaluation of the ability of key habitat components to fulfill the life requisites of selected species of fish and wildlife. The condition of existing habitat components are compared to the documented optimum habitat conditions of the species of interest. Optimum conditions for wildlife are those associated with the highest potential densities of species within a defined area. The HSI ranges from 0.0 to 1.0, with 1.0 representing the most favorable habitat condiction possible at a site, and each increment representing an equal change in magnitude. An important underlying assumption of HEP is that the HSI is linearly related to carrying capacity.

Habitat Units are actually calculated by multiplying the HSI by the total area of that habitat type:

$$HU = HSI \times Area.$$

The HU is, therefore, an expression of both the quality and quantity of habitat available to a specific species.

In applying HEP in mitigation studies, habitat losses are determined and the areas designated for compenstaion are evaluated for various management alternatives to determine the habitat gains attributable to selected mitigation measures. The analyses can be for in-kind compensation (one HU is provided for each HU lost for an evaluation species), equal replacement (a gain of one HU for a species to offset the loss of one HU for another, equally important species), and relative trade-off. The relative trade-off analysis involves using Relative Value Indices (RVI) that reflect human value judgements about the relative value of one species compared to another. For example, if trout have a perceived RVI of 1.0 and whitefish have an RVI of 0.5, one HU for trout would equal two HU's for whitefish (Armour et al. 1984).

FWS is convinced that HEP offers the best existing method for evaluating habitat quality, and has committed to the large-scale development of HSI models for a variety of vertebrate and invertebrate species. Most application of HEP has been in terrestrial habitats. Although many models have been developed for species or life stages of species that occur in estuaries and coastal wetlands (see list of 29 species in Appendix 2), HEP has not yet been utilized in the marine environment.

Even though the formal Habitat Evaluation Procedures have not been applied in marine systems, a modified version of HEP has been. Where the formal version utilizes Habitat Suitability models for individual species, the modified version substitutes the "best professional judgement" of local experts to estimate habitat value

(J. Fancher, FWS, personal communication). Used this way, HEP is a process that documents assumptions and tracks the progress of a habitat evaluation. All available information is utilized with a modified HEP, but no species models are necessary. The modified HEP has been used by the Laguna Niguel field office of FWS to evaluate various harbor development projects and mitigation alternatives (Fancher, personal communication).

Although HEP has been officially adopted by FWS, other government agencies have their own methods for habitat evaluation. A recent review of more than 36 methodologies by the Corps of Engineers (COE) suggested that HEP had the most merit of all the methodologies examined, with COE's Habitat Evaluation System (HES) also receiving a high ranking (Lipton et al. 1984). Nonetheless, there are severe deficiencies in HEP as it might be applied to marine systems. A recent Habitat Evaluation Working Group (HEWG) for the National Marine Fisheries Service (NMFS) concluded that "existing standardized habitat evaluation methods are not applicable in marine and estuarine habitats, nor do they measure habitat value" (Lipton et al. 1984).

One of the Habitat Evaluation Working Group's greatest criticisms of HEP was that the habitat unit has no economic relevance. The habitat unit measures the ability of a habitat to produce fish relative to the maximum carrying capacity of that species; the HEWG argues that society does not value the relative ability of a habitat to produce fish, but rather the fish themselves. The assumption that the HSI is linearly related to

carrying capacity does not allow for density-dependent effects or thresholds. HEWG also argues that HEP is very sensitive to the selection of species to be used in the analysis, and to the methods used to aggregate life stages or different species.

Finally, I have argued that all habitat evaluation methodologies, including HEP, may be inadequate for some of the impacts that result from power plant operations. The direct loss of organisms due to impingement and entrainment results in a loss or resources, but little or no alteration of the habitat. Furthermore, the population dynamics and life histories of many marine organisms differ from their terrestrial counterparts, making the application of evaluation techniques that rely on local habitat conditions problematic.

APPENDIX 3

Correspondence with U.S. Fish and Wildlife Service

United States Department of the Interior
FISH AND WILDLIFE SERVICE
NATIONAL COASTAL ECOSYSTEMS TEAM
NASA - SLIDELL COMPUTER COMPLEX
1010 GAUSE BOULEVARD
SLIDELL, LOUISIANA 70458

November 6, 1985

Dr. Richard F. Ambrose
Department of Biological Sciences
University of California
Santa Barbara, CA 93106

Dear Dr. Ambrose:

Dr. Carroll Cordes has asked me to respond to your letter of October 17, 1985, regarding marine HEP applications and mitigation projects since I am familiar with your region.

No HSI models have been developed for marine species of the Pacific Southwest of the U. S. Although a few models for Atlantic and Gulf of Mexico Coast species nominally apply in marine as well as estuarine conditions, the strong focus of NCET's habitat modeling activities is on species or life stages of species that occur in estuaries and coastal wetlands. Models are available for:

southern kingfish	clapper rail	hard clam
striped bass (coastal stocks)	redhead (wintering)	littleneck clam
red drum	great egret	Gulf of Mexico oyster
Gulf menhaden	roseate spoonbill	pink shrimp
spotted seatrout	mottled duck	white shrimp
alewife	American black duck (wintering)	brown shrimp
blueback herring	white ibis	
Atlantic croaker	eastern brown pelican	
juvenile spot	laughing gull	
American shad	lesser scaup (wintering)	
southern flounder	lesser snow goose (wintering)	
Gulf flounder		

I am not aware of any marine applications of HEP, nor any plans for Fish and Wildlife Service to become involved in marine applications.

One negotiation of mitigation for habitat loss in your region may be pertinent to the situation at SONGS (see the enclosed "Memorandum of Understanding"). The process used to arrive at mitigation requirements for habitat loss in Long Beach Harbor was analogous to an application of HEP, except that individual species could not be used as "evaluation elements", for lack of appropriate HSI models. This difference prevented identification of gradations of quality within a habitat type and reduced the assessment of mitigation requirements to a constant

of proportionality between two shallow-water types. Such a trade-off is more a matter of agency policy and negotiation among involved parties than technical assessment of habitat loss and alternative actions to compensate for those losses by improvements in habitat quality elsewhere. Unless the plan for mitigation at SONGS is to create or improve kelp habitat elsewhere, the settlement is likely to be of the sort worked out for Long Beach Harbor. The determination of the relative values of grossly different kinds of habitat is a matter of interpreting policy, not the application of a method of habitat assessment which assumes that the same resources are at issue. This is the role of the Division of Ecological Services through its Field Office at Laguna Niguel.

The National Marine Fisheries Service undoubtedly will be involved in any determination of mitigation objectives and requirements and should be consulted. NMFS does not have a set procedure of habitat assessment; however, the enclosed evaluations of HEP may provide an indication of their approach to the problem.

The Fish and Wildlife Coordination Act Report, "Mobile Harbor, Alabama Project", is an example of HEP applied to estuarine mitigation assessment. Few others exist. No guidelines are available for conceiving and screening mitigation alternatives. The rules to keep in mind are that any creation of new habitat of the same kind as lost must be in areas of manifestly lower value in its present form than what is to replace it, and that if replacement is not in kind, the replacement must be of the same or a higher resource category than what is lost. (See the USFWS Mitigation Policy). If resource categories have been established for marine resources in your region, the Mitigation Policy is even more restrictive. On the assumption that kelp beds are at least as valuable as any other habitat in open coastal areas, in-kind mitigation (creation of new kelp beds, enhancement of existing kelp beds) is likely to be most widely acceptable (if feasible). The only out-of-kind mitigations that might be acceptable are creation or enhancement of coastal wetlands (in the broad sense of shallow, protected, open water surrounded by marsh) or a hatchery program for the species of greatest local concern. Doubtless, you are already aware that the Southern California Edison Company and California Department of Fish and Game independently are investigating the feasibility of hatchery programs. The precedent of hatcheries as mitigation for loss of salmonid spawning runs is relevant; however, single species measures are less likely to be viewed as adequate compensation where a habitat type is valued for its support of a complex assemblage of organisms rather than for support of a single life stage of a dominant and highly valued single species.

I hope these comments are of some use to you in developing a set of mitigation alternatives and in anticipating how different classes of proposals might be received by reviewing agencies. Please keep us informed about your activities and contact us at any time that we might be of further assistance. Successful mitigation is crucial to the mission of the Service; however, mitigation remains

very much a trial and error endeavor. We can provide technical assistance when the scope of the mitigation becomes defined. In turn, we shall benefit from having to re-evaluate our approaches for applicability in a new environment.

Sincerely,

Christopher P. Onuf
Ecologist
Telephone (504) 646-7323

Enclosures:
1. Memorandum of Understanding
2. NMFS Report on Evaluating Marine and Estuarine Habitat
3. Coordination Act Report on Mobile Harbor Project
4. USFWS Mitigation Policy
5. Kelp Forest Community Profile
6. Littleneck Clam HSI Model

APPENDIX 4

Partial list of species at San Onofre Kelp Bed and nearby areas

This species list was compiled from Southern California Edison Annual Reports covering 1982, 1983 and 1984, DeMartini (1983), and the master species list maintained by the Kelp Invertebrate Project (Herrlinger, personal communication). Abbreviations used are: BK=Barn Kelp, SOKUP=San Onofre Kelp-Upcoast, SOKDN=San Onofre Kelp-Downcoast, SMK=San Mateo Kelp, 0=1980, 1=1981, 2=1982, 3=1983, 4=1984, *=Kelp Invertebrate Project list with no location noted, imp=impinged (data from SCE Reports).

TAXON	SPECIES	BK	SOKUP	SOKDN	SMK
CHLOROPHYT	Bryopsis sp.		3	4	
CHLOROPHYT	Cladophora sp.	34	34	4	4
CHLOROPHYT	Enteromorpha sp.	4			4
CHLOROPHYT	Unidentified nodular	34	34	4	4
PHAEOPHYTA	Cystoseira osmundacea	234	234	234	234
PHAEOPHYTA	Desmarestia munda	34	4	4	4
PHAEOPHYTA	Desmarestia ligulata			2	
PHAEOPHYTA	Dictyopteris zonarioides			4	34
PHAEOPHYTA	Dictyota flabellata	234	234	234	34
PHAEOPHYTA	Ectocarpus sp.	34	34	34	34
PHAEOPHYTA	Egregia laevigata			2	2
PHAEOPHYTA	Laminaria farlowii	234	34		
PHAEOPHYTA	Macrocystis pyrifera	4	234	234	234
PHAEOPHYTA	Pachydictyon coriaceum	3	23	234	34
PHAEOPHYTA	Pterygophora californica	234	34	34	34
PHAEOPHYTA	Ralfsia sp.nr.fungiformis	4	4	4	4
PHAEOPHYTA	Sargassum agardhianum	24		34	4
PHAEOPHYTA	Taonia lennebackerae	4	4	34	34
PHAEOPHYTA	Zonaria farlowii	4		4	4
PHAEOPHYTA	Acrochaetium sp.		4		
PHAEOPHYTA	* Egregia menziesii				
PHAEOPHYTA	* Eisenia arborea				
PHAEOPHYTA	* Colpomenia/Hydroclathrus sp.				
RHODOPHYTA	Acrosorium uncinatum	24	234	234	34
RHODOPHYTA	Anisocladella pacifica			24	3
RHODOPHYTA	Antithamnion sp.	34	34	34	34
RHODOPHYTA	Antithamnionella sp.		4	4	4
RHODOPHYTA	Bossiella gardneri	3	3	3	3
RHODOPHYTA	Bossiella sp.	24	24	24	24
RHODOPHYTA	Botryocladia pseudodichotoma	34		4	34
RHODOPHYTA	Callithamnion sp.	4	4	4	4
RHODOPHYTA	Callophyllis firma			4	4

RHODOPHYTA	Callophyllis falbellulata	3	234	234	34
RHODOPHYTA	Callophyllis violacea	2	234	24	24
RHODOPHYTA	Centroceras clavulatum	4	4	4	4
RHODOPHYTA	Ceramium taylori			4	
RHODOPHYTA	Ceramium sp.	4	34	34	34
RHODOPHYTA	Coelosira compressa	3	3	24	234
RHODOPHYTA	Corallina officinalis	234	234	24	234
RHODOPHYTA	Corallina pinnatifolia	4	4	4	
RHODOPHYTA	Corallina vancouveriensis			3	
RHODOPHYTA	Cryptonemia obovata	4	34	34	24
RHODOPHYTA	Cryptopleura crispa		3		3
RHODOPHYTA	Dasya sinicola			4	
RHODOPHYTA	Derbesia marina		3		
RHODOPHYTA	Farlowia compressa			2	
RHODOPHYTA	Gelidium nudifrons	234	234	234	234
RHODOPHYTA	Gelidium robustum		3	4	3
RHODOPHYTA	Gigartina canaliculata	3	4	4	4
RHODOPHYTA	Gigartina exasperata		34	234	24
RHODOPHYTA	Gloiophloea confusa		34	34	34
RHODOPHYTA	Gracillaria cunninghami		4		
RHODOPHYTA	Gracillaria sjoestedtii		34	34	4
RHODOPHYTA	Gracillaria verrucosa			4	
RHODOPHYTA	Grateloupia doryphora		4	4	
RHODOPHYTA	Grateloupia sp.		3	2	
RHODOPHYTA	Griffithsia furcellata		4	4	4
RHODOPHYTA	Griffithsia sp.			4	
RHODOPHYTA	Gymnogongrus leptophyllus		4		4
RHODOPHYTA	Gymnogongrus platyphyllus	234	234	24	4
RHODOPHYTA	Haliptylon gracile	4	4	4	
RHODOPHYTA	Halymenia californica			2	23
RHODOPHYTA	Halymenia sp.		4	4	4
RHODOPHYTA	Herposiphonia sp.	3	4		
RHODOPHYTA	Heterosiphonia sp.			4	
RHODOPHYTA	Hildenbrandia sp.		4	4	4
RHODOPHYTA	Hypnea johnstoni			4	
RHODOPHYTA	Iridaea cordata			4	
RHODOPHYTA	Jania crassa			4	34
RHODOPHYTA	Laurenica decidua	34	3		
RHODOPHYTA	Laurencia lajolla			23	
RHODOPHYTA	Laurencia pacifica		4		
RHODOPHYTA	Laurencia spectabilis		23		
RHODOPHYTA	Laurencia subdisticha	4			
RHODOPHYTA	Laurencia subopposita	24	23	4	2
RHODOPHYTA	Laurencia sp.		4	4	4
RHODOPHYTA	Leptocladia binghamiae		23		2
RHODOPHYTA	Lithothamnium sp.	234	234	234	234
RHODOPHYTA	Ozophora californica				3
RHODOPHYTA	Peyssonellia rubra	2	2	2	2
RHODOPHYTA	Peyssonellia sp.	34	34	34	34
RHODOPHYTA	Phycodrys profunda			4	4
RHODOPHYTA	Phyllophora californica		4		2

RHODOPHYTA	Pikea californica	4		4	4
RHODOPHYTA	Platysiphonia sp.		4	4	
RHODOPHYTA	Platythamnion sp.			4	4
RHODOPHYTA	Plocamium pacificum			4	3
RHODOPHYTA	Polyneura latissima	4	4	24	3
RHODOPHYTA	Polyopes bushiae	3			
RHODOPHYTA	Polysiphonia paniculata			3	
RHODOPHYTA	Polysiphonia sp.	34	34	234	4
RHODOPHYTA	Prionitis angusta	24	24	24	24
RHODOPHYTA	Prionitis australis	24	2	4	24
RHODOPHYTA	Prionitis cornea		2	2	2
RHODOPHYTA	Pterocladia caloglossiodes		4	4	4
RHODOPHYTA	Pterocladia capillacea		4	4	4
RHODOPHYTA	Pterocladia media	4	4	4	
RHODOPHYTA	Pterocladia pyramidale		2		
RHODOPHYTA	Pterosiphonia baileyi				4
RHODOPHYTA	Pterosiphonia dendroidea	4	4	4	4
RHODOPHYTA	Pterosiphonia pennata		4	4	4
RHODOPHYTA	Pterosiphonia spp.	24	24	24	4
RHODOPHYTA	Rhodoptilum densum		4		4
RHODOPHYTA	Rhodymenia arborescens	3	4	34	34
RHODOPHYTA	Rhodymenia californica	234	234	234	234
RHODOPHYTA	Rhodymenia pacifica	2	2	2	2
RHODOPHYTA	Schizymenia epiphytica			4	
RHODOPHYTA	Schizymenia pacifica			4	
RHODOPHYTA	Schizymenia sp.			4	
RHODOPHYTA	Stenogramme interrupta				2
RHODOPHYTA	Tiffaniella snyderi	4	4	34	34
RHODOPHYTA	Unidentified filamentous	4	3	4	
RHODOPHYTA	Unidentified juvenile	4	4	4	4
RHODOPHYTA	* Gigartina corymbifera				
RHODOPHYTA	* Gigartina spinosa				
RHODOPHYTA	* Nienburgia andersoniana				
RHODOPHYTA	* Plocamium cartilagineum				
RHODOPHYTA	* Ptilota filicina				
VASCULAR	* Phyllospadix spp.				
PROTOZOA	Gromia oviformis	4	34	34	34
PROTOZOA	Rosalina sp.	3	3	3	3
PROTOZOA	Unidentified Foraminifera	4	4	4	4
PORIFERA	Anaata sp.				4
PORIFERA	Astylinifer arndti		2	2	2
PORIFERA	Axinella mexicana	2		234	234
PORIFERA	Cliona celata				3
PORIFERA	Cyamon argon	234	234	234	234
PORIFERA	Dysidea amblia	234			
PORIFERA	Halichondria panicea	23	2	2	23
PORIFERA	Haliclona ecbasis	23			2
PORIFERA	Haliclona lunisimilis	23	2	234	234

PORIFERA	Haliclona permollis	2	2	24	24
PORIFERA	Haliclona sp.	4	4	4	4
PORIFERA	Hymenamphiastra cyanocrypta	2	2	24	24
PORIFERA	Hymeniacodon sinapium	23	3	4	
PORIFERA	Hymeniacodon ungodon	23			
PORIFERA	Fiuclina suberea				2
PORIFERA	Isociona lithophoenix	24			2
PORIFERA	Leucetta losangelensis			4	24
PORIFERA	Leuconia heathii	34	23	234	24
PORIFERA	Leucosolenia eleanor	4	4	4	4
PORIFERA	Leucosolenia maclayi		4	4	4
PORIFERA	Leucosolenia nautila	4	4	4	4
PORIFERA	Microciona microjoanna			3	
PORIFERA	Microciona parthena	23		3	2
PORIFERA	Microciona sp.	24		2	34
PORIFERA	Mycale macginitiei			4	
PORIFERA	Myxilla spp.	4	2		
PORIFERA	Unid. Myxospongida	4			
PORIFERA	Paresperella psila			4	
PORIFERA	Plocamia karykina	234	234	234	234
PORIFERA	Unid. Plocamiidae		4		
PORIFERA	Plocamissima igzo	24			
PORIFERA	Unid. Poecilosclerina			4	
PORIFERA	Prosuberites sisyrmus	4	4	4	4
PORIFERA	Raspailiidae				34
PORIFERA	Reniera spp.	2			
PORIFERA	Rhabdodermella nuttingi	24	23	234	234
PORIFERA	Speciospongia confoederata	3			
PORIFERA	Spongia ida	23			
PORIFERA	Unid. Suberitidae				4
PORIFERA	Tedanione obscurata	234		2	4
PORIFERA	Tethya aurantia	234	2	234	234
PORIFERA	Timea authia			4	
PORIFERA	Unidentified red			3	
PORIFERA	Unidentified spong	2			2
PORIFERA	Verongia thione	4			
PORIFERA	* Acarnus erithacus				
COELENTERA	Abietinaria sp.	4	4	34	4
COELENTERA	Aglaophenia struthenoides		234	234	34
COELENTERA	Anthopleura artemesia	24	2	234	24
COELENTERA	Anthopleura elegantissima	34	234	24	4
COELENTERA	Astrangia lajollaensis	2		34	234
COELENTERA	Cactosoma arenaria				4
COELENTERA	Clytia bakeri			4	
COELENTERA	Corynactis californica	23	3	234	234
COELENTERA	Epiactis prolifera		34	234	34
COELENTERA	Halecium sp.			3	
COELENTERA	Lophogorgia chilensis	34		34	23
COELENTERA	Muricea californica	234	234	234	234
COELENTERA	Muricea fruticosa	234	234	234	234

COELENTERA	Pachycerianthus sp.	234	34	234	234
COELENTERA	Paracyanthus stearnsii	234	23	234	234
COELENTERA	Plumularia sp.		4	4	
COELENTERA	Sertularella sp.	34	34	234	34
COELENTERA	Tealia sp.	234	2	24	234
COELENTERA	Unid. Hydroid	4	4	4	4
COELENTERA	Unidentified hydroid	4	234	234	234
COELENTERA	* Anthopleura xanthogrammica				
COELENTERA	* Balanophyllia elegans				
COELENTERA	* Campanularia spp.				
COELENTERA	* Obelia spp.				
COELENTERA	* Pachycerianthus fimbriatus				
COELENTERA	* Renilla koellikeri				
COELENTERA	* Tubularia crocea				
PLATYHELMI	Prosthoceraeus bellostriatus			4	
PLATYHELMI	Thysanozoon sp.				4
PLATYHELMI	Unid. flatworm			4	
NEMATODA	Unid. Nematode			4	
SIPUNCULID	Phascolosoma agassizii			4	
SIPUNCULOI	Unidentified			34	
ANNELIDA	Chaetopterus variopedatus	4		3	
ANNELIDA	Dexiospira spirillum	234	234	234	234
ANNELIDA	Diopatra ornata	4	234	234	234
ANNELIDA	Eudistylia polymorpha	23			
ANNELIDA	Unid. Euphrosinidae			4	
ANNELIDA	Hydroides pacificus	4	4	4	4
ANNELIDA	Phragmatopoma californica	2	234	234	23
ANNELIDA	Unid. Phyllodocidae			4	
ANNELIDA	Pista elongata				3
ANNELIDA	Pista spp.			24	4
ANNELIDA	Platynereis bicanaliculata	2		234	3
ANNELIDA	Platynereis bicanaliculata			4	
ANNELIDA	Polynoid	2	2		2
ANNELIDA	Protolaeospira capensis			4	4
ANNELIDA	Protolaeospira eximia	4		4	4
ANNELIDA	Sabellaria cementarium	34	34	34	34
ANNELIDA	Sabellid	2			
ANNELIDA	Sabellidae	34		4	
ANNELIDA	Salmacina tribranchiata	234		4	24
ANNELIDA	Serpulidae			3	
ANNELIDA	Spirobranchis spinosus	4		24	4
ANNELIDA	Spirorbis bifurcatus	4		4	4
ANNELIDA	Spirorbis borealis	4	4	4	4
ANNELIDA	Telepsavus costarum	2			
ANNELIDA	Unid. Nereid	4			
ANNELIDA	Unid. Polycheata			4	
ANNELIDA	Unid. Polynoid	4		4	4

ANNELIDA	* Cirriformia sp.				
ANNELIDA	* Eupomatus gracilis				
ANNELIDA	* Serpula vermicularis				
ANNELIDA	* Spirorbis spp.				
NEMERTINEA	Unidentified		3		
BRYOZOA	Adeonid			2	
BRYOZOA	Aetea anguina	34	34	34	34
BRYOZOA	Aetea ligulata	34	34	34	34
BRYOZOA	Aetea recta	3	3	34	
BRYOZOA	Aetea truncata	34	4	34	34
BRYOZOA	Aetea sp.	4		4	
BRYOZOA	Alcyonidium mammilatum			4	
BRYOZOA	Alcyonidium polyoum				4
BRYOZOA	Antropora tincta	34	34	34	34
BRYOZOA	Aplousina major	4	3	4	
BRYOZOA	Aplousina sp.		3	3	
BRYOZOA	Arthropoma cecili	34			4
BRYOZOA	Bicellariella sp.	3			
BRYOZOA	Borgiola pustulosa		3		
BRYOZOA	Bugula longirostrata		4	4	
BRYOZOA	Bugula neritina	4	4		
BRYOZOA	Bugula pacifica			4	
BRYOZOA	Bugula uniserialis			4	
BRYOZOA	Bugula sp.	34		3	
BRYOZOA	Callopora armata			3	
BRYOZOA	Callopora circumclathrata		3	4	
BRYOZOA	Callopora corniculifera	4			
BRYOZOA	Callopora horrida			4	
BRYOZOA	Callopora lineata				3
BRYOZOA	Callopora sp.	4		3	
BRYOZOA	Caulibugula californica			34	
BRYOZOA	Caulibugula ciliata	4	34	34	4
BRYOZOA	Caulibugula occidentalis		4		3
BRYOZOA	Cauloramphus echinus	4		4	4
BRYOZOA	Cauloramphus spiniferum	34	34	34	
BRYOZOA	Cellaria mandibulata	234	234	234	234
BRYOZOA	Chapperia patula	4		34	
BRYOZOA	Clavopora occidentalis	3	3		3
BRYOZOA	Colletosia radiata	34		34	34
BRYOZOA	Conopeum spp.			2	
BRYOZOA	Copidozoum planum			3	
BRYOZOA	Costazia costazi			4	
BRYOZOA	Costazia procumbens	2			
BRYOZOA	Costazia robertsoni	234	23	234	234
BRYOZOA	Costazia sp.	3	3	34	34
BRYOZOA	Costazia ventricosa	4		3	4
BRYOZOA	Crisia occidentalis	4	34	34	4
BRYOZOA	Crisia serrulata	4		4	4
BRYOZOA	Crisia sp.	234	234	234	234

BRYOZOA	Crisulipora occidentalis	4	4	4	4
BRYOZOA	Dakaria ordinata	4		3	
BRYOZOA	Dakaria sp.				4
BRYOZOA	Diaporoecia californica	34		34	4
BRYOZOA	Diaporoecia floridana	3			
BRYOZOA	Diaporoeci spp.	2			2
BRYOZOA	Disporella californica	4	4	4	4
BRYOZOA	Disporella fimbriata		4	4	34
BRYOZOA	Disporella hispida			4	
BRYOZOA	Disporella pacifica		4		
BRYOZOA	Disporella sp.	4	34	4	34
BRYOZOA	Electra crustulenta		3		
BRYOZOA	Electra spp.			2	2
BRYOZOA	Eurystomella bilabiata			4	
BRYOZOA	Fasciculipora pacifica	34	3	34	3
BRYOZOA	Fasciculipora sp.	3			
BRYOZOA	Fenestrulina malusi	34	34	34	34
BRYOZOA	Filicrisia franciscana		3		
BRYOZOA	Filicrisia geniculata	4	34	34	4
BRYOZOA	Filicrisia sp.	34	34	34	34
BRYOZOA	Flustrella corniculata			4	
BRYOZOA	Gemelliporella globulifera			3	
BRYOZOA	Hincksina alba			4	
BRYOZOA	Hincksina pacifica		3	34	34
BRYOZOA	Hinksina velata	3		34	4
BRYOZOA	Hinksina sp.	4		3	4
BRYOZOA	Hincksinidae			3	
BRYOZOA	Hippodiplosia insculpta	234	2		
BRYOZOA	Hippoporella gorgonensis	4	4	34	4
BRYOZOA	Hippoporella nitescens	34	34	34	34
BRYOZOA	Hippoporella sp.	4			
BRYOZOA	Hippoporidra sp.			4	
BRYOZOA	Hippoporina californica	2	2	2	2
BRYOZOA	Hippoporina porcellana				4
BRYOZOA	Hippoporina contracta	2		2	2
BRYOZOA	Hippothoa expansa	4		4	
BRYOZOA	Hippothoa flagellum	34	3	34	34
BRYOZOA	Hippothoa hyalina	34	34	234	34
BRYOZOA	Holoporella brunnea	34	34	34	34
BRYOZOA	Holoporella sp.			3	
BRYOZOA	Holoporellid			2	
BRYOZOA	Hornera pectinata	3		3	
BRYOZOA	Lacerna fistulata			3	
BRYOZOA	Lagenipora hippocrepis	3		3	3
BRYOZOA	Lagenipora lacunosa	3	23	23	23
BRYOZOA	Lagenipora mexicana				4
BRYOZOA	Lagenipora punctulata	4		34	
BRYOZOA	Lagenipora socialis				34
BRYOZOA	Lagenipora spinulosa	3	2		
BRYOZOA	Lichenopora buskiana	3			
BRYOZOA	Lichenopora novae-zealandi			3	

BRYOZOA	Lichenopora sp.		3	3	
BRYOZOA	Lichenopora verrucaria	3	3		
BRYOZOA	Lyrula hippocrepis	234	234	234	234
BRYOZOA	Membranipora fusca	234	234	234	234
BRYOZOA	Membranipora membrancea	24	234	234	234
BRYOZOA	Membranipora savarti	4		4	
BRYOZOA	Membranipora tuberculata	4	34	34	4
BRYOZOA	Membranipora villosa	4	3	4	
BRYOZOA	Micropora coriacea	3	2	23	23
BRYOZOA	Microporella californica	234	234	234	234
BRYOZOA	Microporella ciliata	234	4	34	34
BRYOZOA	Microporella coronata				
BRYOZOA	Microporella cribrosa	34	34	34	4
BRYOZOA	Microporella gibbosula	34	3	34	34
BRYOZOA	Microporella setiformis			4	
BRYOZOA	Microporella pontifica	3		3	3
BRYOZOA	Microporella umbonata	34	34	234	
BRYOZOA	Microporella vibraculifera	34	24	234	34
BRYOZOA	Mucronella major	4	4	34	34
BRYOZOA	Mucronella sp.			3	3
BRYOZOA	Onochyochella alula			4	
BRYOZOA	Onsuoecia sp.			3	3
BRYOZOA	Parasmittina californica	34	34	34	34
BRYOZOA	Parasmittina collifera	4	4	4	4
BRYOZOA	Parasmittina crosslandi			3	
BRYOZOA	Parasmittina spathulifera			3	
BRYOZOA	Parasmittina sp.			3	
BRYOZOA	Parasmittina trispinosa	34	4	4	4
BRYOZOA	Parasmittina tubulata		4		
BRYOZOA	Pherusella brevituba		23		
BRYOZOA	Phidolopora pacifica				2
BRYOZOA	Plagioecia anacapensis			4	3
BRYOZOA	Plagioecia patina			4	
BRYOZOA	Plagioecia sarniensis		4	4	3
BRYOZOA	Plagioecia sp.	4	4	34	34
BRYOZOA	Plagioecia tortuosa				3
BRYOZOA	Plagioecia tubiabortiva	4		4	
BRYOZOA	Porella compressa	3		3	
BRYOZOA	Porella porifera	234	4	34	34
BRYOZOA	Porella spp.			2	
BRYOZOA	Proboscina major	4		4	4
BRYOZOA	Puellina setosa	34		34	34
BRYOZOA	Ramphostomella curvirostrata	3		3	
BRYOZOA	Reginella furcata		3		
BRYOZOA	Reginella mattoidea			3	
BRYOZOA	Reginella murcronata	3			
BRYOZOA	Reginella nitida			3	
BRYOZOA	Retevirgula areolata	34	34	34	4
BRYOZOA	Retevirgula tubulata	4	34	4	4
BRYOZOA	Rhynchozoon bispinosum	3	3	3	3
BRYOZOA	Rhynchozoon grandicella	34	34	34	34

BRYOZOA	Rhynchozoon rostratum	234	234	234	234
BRYOZOA	Rhynchozoon spicatum	34	234	234	234
BRYOZOA	Rhynchozoon tuberculatum			4	
BRYOZOA	Rhynchozoon tumulosum	34	34	34	34
BRYOZOA	Schizomavella auriculata	34	34	34	34
BRYOZOA	Schizoporella cornuta	34	34	34	34
BRYOZOA	Schizoporella linearis	34		34	34
BRYOZOA	Schizoporella sp.				3
BRYOZOA	Schizoporella unicornis			2	
BRYOZOA	Schizoporellidae			3	
BRYOZOA	Schizotheca fissurella	4		34	
BRYOZOA	Scrupocellaria bertholetti	4	2	4	
BRYOZOA	Scrupocellaria diegensis	4	23	234	2
BRYOZOA	Scrupocellaria ferox			4	
BRYOZOA	Scrupocellaria sp.	34	34	34	3
BRYOZOA	Scrupocellaria talonis	34		4	
BRYOZOA	Scrupocellaria varians	4	4	4	4
BRYOZOA	Smittina cordata	3		234	34
BRYOZOA	Smittina spathulifera			3	3
BRYOZOA	Smithoidea prolifica	4		3	
BRYOZOA	Sonittoidea spp.				2
BRYOZOA	Stomatopora granulata	4			
BRYOZOA	Thalamoporella californica	234	234	234	24
BRYOZOA	Trypematella umbonula			4	
BRYOZOA	Tubulipora admiranda	4	3	34	
BRYOZOA	Tublipora concinna	3		34	4
BRYOZOA	Tublipora flabellaris			34	
BRYOZOA	Tublipora pacifica		34	34	3
BRYOZOA	Tublipora pulchra		4	4	
BRYOZOA	Tublipora sp.	34	34	34	4
BRYOZOA	Tublipora tuba		4	34	4
BRYOZOA	Unidentified Ascophora	3			
BRYOZOA	Veleroa veleronis	34		4	
BRYOZOA	Victorella argyra	23	4	4	2
BRYOZOA	Watersiporia cucullata	3			
BRYOZOA	* Alcyonidium sp.				
BRYOZOA	* Celleporaria brunnea				
MOLLUSCA	Acanthodoris spp.		2	2	24
MOLLUSCA	Acmaea insessa			3	
MOLLUSCA	Acmaea mitra			3	
MOLLUSCA	Acmaea pelta			3	
MOLLUSCA	Acmaea sp.		4	34	34
MOLLUSCA	Acmaeid unidentified			2	
MOLLUSCA	Aletes squamigerus	4		34	
MOLLUSCA	Aplysia californica		4	4	
MOLLUSCA	Astraea gibberosa			23	
MOLLUSCA	Astraea undosa		234	234	34
MOLLUSCA	Basilochiton sp.			3	
MOLLUSCA	Bittium sp.			3	
MOLLUSCA	Burchia redondoensis	34		234	34

MOLLUSCA	Bursa californica			4	
MOLLUSCA	Cadlina flavomaculata			2	
MOLLUSCA	Calliostoma sp.	3	2		2
MOLLUSCA	Calliostoma variegata			4	
MOLLUSCA	Callistochiton sp.			34	
MOLLUSCA	Chama pellucida	34	34	234	34
MOLLUSCA	Chiton unidentified		2		
MOLLUSCA	Conus californica	4	234	234	34
MOLLUSCA	Crepidula sp.	3	3	23	3
MOLLUSCA	Crepipatella sp.	23	23	23	23
MOLLUSCA	Cyclostrema cookeanum	3		3	3
MOLLUSCA	Cyclostremella sp.			3	3
MOLLUSCA	Dendrochiton sp.		4	4	
MOLLUSCA	Dendrodoris albopunctata	2			
MOLLUSCA	Dendrodoris sp.		4	4	4
MOLLUSCA	Elephantellum sp.	4	3	4	3
MOLLUSCA	Entodesma sp.			4	4
MOLLUSCA	Flabellinopsis iodinea	34		34	3
MOLLUSCA	Gari californica	2			
MOLLUSCA	Haliotis corrugata		34	4	34
MOLLUSCA	Haliotis fulgens			2	
MOLLUSCA	Haliotis rufescens			4	4
MOLLUSCA	Haliotis sp.			23	
MOLLUSCA	Hermissenda crassicornis				3
MOLLUSCA	Hiatella arctica	34		23	
MOLLUSCA	Hinnites multirugosus	24		34	3
MOLLUSCA	Irus lamellifer				4
MOLLUSCA	Ischnochiton sp.			4	4
MOLLUSCA	Iselica obtusa			4	
MOLLUSCA	Jaton festivus		24	234	234
MOLLUSCA	Kellettia kellettii	234	234	234	234
MOLLUSCA	Leptochiton sp.	4	4	4	
MOLLUSCA	Leptopecten latiauritus	4		34	4
MOLLUSCA	Maxwellia gemma				2
MOLLUSCA	Maxwellia sp.		4	4	
MOLLUSCA	Megathura crenulata	234			
MOLLUSCA	Micranellum sp.		3	3	
MOLLUSCA	Mitra idae	24		24	24
MOLLUSCA	Mitrella carinata		34	34	4
MOLLUSCA	Mitrella spp.		2	2	
MOLLUSCA	Murex santarosana	3		3	3
MOLLUSCA	Murex santarosansus	4		4	4
MOLLUSCA	Norrisia norrisii		3	2	
MOLLUSCA	Ocenebra sp.		3		
MOLLUSCA	Octopus sp.			24	234
MOLLUSCA	Petaloconchus compactus	4	4	4	4
MOLLUSCA	Pododesmus macroschisma			2	2
MOLLUSCA	Prototheca staminea			3	
MOLLUSCA	Pseudochama exogyra	4		3	
MOLLUSCA	Pteropurpura trialatus			34	4
MOLLUSCA	Pteropurpura vokezae			3	3

MOLLUSCA	Rissoella californica			4	
MOLLUSCA	Seila sp.			3	
MOLLUSCA	Siliquaria sp.	4	4	4	4
MOLLUSCA	Sprioglyphis lituella	34	34	34	34
MOLLUSCA	Spiroglyphis sp.	3	3	3	3
MOLLUSCA	Stenoplax sp.		4		
MOLLUSCA	Tegula aureotincta		4	234	
MOLLUSCA	Tegula regina			2	
MOLLUSCA	Tegula sp.		3		
MOLLUSCA	Thylaeodus sp.	34	4	3	3
MOLLUSCA	Trinchesia lagunae		2		
MOLLUSCA	Trivia spp.			4	2
MOLLUSCA	Turritellopsis sp.		3		
MOLLUSCA	Williamia sp.	3	3	23	3
MOLLUSCA	Zonaria spadicea			234	
MOLLUSCA	Unid. Aeolid			4	
MOLLUSCA	Unid. Chiton			4	4
MOLLUSCA	Unidentified gastropod		2		
MOLLUSCA	* Acanthodoris rhodoceras				
MOLLUSCA	* Aglaja inermis(Chelidonura)				
MOLLUSCA	* Aldisa sanguinea				
MOLLUSCA	* Alia carinata				
MOLLUSCA	* Amphissa versicolor				
MOLLUSCA	* Aplysia vaccaria				
MOLLUSCA	* Barbatia bailyi				
MOLLUSCA	* Barleeia acuta				
MOLLUSCA	* Bulla gouldiana				
MOLLUSCA	* Calliostoma annulatum				
MOLLUSCA	* Ceratostoma nuttali				
MOLLUSCA	* Cerithiopsis sp.				
MOLLUSCA	* Chama arcana				
MOLLUSCA	* Chlamydoconcha sp.				
MOLLUSCA	* Chromodoris macfarlandi				
MOLLUSCA	* Crassispira semiinflata				
MOLLUSCA	* Crepidula dorsata				
MOLLUSCA	* Cypraea spadicea				
MOLLUSCA	* Diaulula sandiegensis				
MOLLUSCA	* Donax gouldii				
MOLLUSCA	* Doriopsilla albopinctata				
MOLLUSCA	* Epitonium tinctum				
MOLLUSCA	* Erato vitellina				
MOLLUSCA	* Fusinus luteopictus				
MOLLUSCA	* Glans subquadrata				
MOLLUSCA	* Hinnites giganteus				
MOLLUSCA	* Kellia laperousii				
MOLLUSCA	* Lacuna unifasciata				
MOLLUSCA	* Latiaxis oldroydi				
MOLLUSCA	* Lima hemphilli				
MOLLUSCA	* Lirularia sp.				
MOLLUSCA	* Macron lividus				
MOLLUSCA	* Melibe leonina				

MOLLUSCA	* Milneria kelseyi				
MOLLUSCA	* Mitrella tuberosa				
MOLLUSCA	* Murexiella santarosana				
MOLLUSCA	* Mytilus edulis				
MOLLUSCA	* Nassarius fossatus				
MOLLUSCA	* Nassarius mendicus				
MOLLUSCA	* Nassarius spp.				
MOLLUSCA	* Olivella spp.				
MOLLUSCA	* Opalia sp.				
MOLLUSCA	* Ophiodermella ophioderma				
MOLLUSCA	* Polycera sp.				
MOLLUSCA	* Pteropurpura festiva				
MOLLUSCA	* Pteropurapura macroptera				
MOLLUSCA	* Pteropurapura vokesae				
MOLLUSCA	* Rostanga pulchra				
MOLLUSCA	* Roperia poulsoni				
MOLLUSCA	* Serpulorbis squamigerus				
MOLLUSCA	* Simnia vidleri				
MOLLUSCA	* Tegula eiseni				
MOLLUSCA	* Terebra danai				
MOLLUSCA	* Tonicella Lineata				
MOLLUSCA	* Tricolia pulloides				
MOLLUSCA	* Trivia californiana				
ARTHROPODA	Balanus tintinnabulum	23	23	23	
ARTHROPODA	Balanus spp.			2	
ARTHROPODA	Cancer spp.		2		
ARTHROPODA	Caprellidae		2	3	
ARTHROPODA	Grapsid, juvenile				2
ARTHROPODA	Isopoda	3		3	3
ARTHROPODA	Loxorhyncus grandis		3		
ARTHROPODA	Paguridae	23	23	23	23
ARTHROPODA	Panulirus interruptus	34	234	234	
ARTHROPODA	Pugettia dalli		4		
ARTHROPODA	Pycnogonum rickettsi			4	
ARTHROPODA	Scyra acutifrons	4	4	2	4
ARTHROPODA	Unid. Cancridea	4			
ARTHROPODA	Unid. Caprellidea		4	4	4
ARTHROPODA	Unid. Gammaridea	4	4	4	
ARTHROPODA	Unid. Grapsidae			4	
ARTHROPODA	Unid. Inachidae	4		4	
ARTHROPODA	Unid. Isopoda	4	4	4	
ARTHROPODA	Unid. Paguridae	4	4	4	4
ARTHROPODA	Unid. Sphaeromidae spp.		4	4	
ARTHROPODA	Unid. Stomatopoda	4	4		
ARTHROPODA	* Ampithoe humeralis				
ARTHROPODA	* Balanus tintinnabulum calif				
ARTHROPODA	* Balanus trigonus				
ARTHROPODA	* Cancer amphioetus				
ARTHROPODA	* Cancer antennarius				
ARTHROPODA	* Cancer anthonyi				

ARTHROPODA	* Cancer branneri				
ARTHROPODA	* Cancer gracilis				
ARTHROPODA	* Cancer jordani				
ARTHROPODA	* Cancer productus				
ARTHROPODA	* Caprella californica				
ARTHROPODA	* Ericthonius sp.				
ARTHROPODA	* Heptacarpus palpator				
ARTHROPODA	* Hippolyte spp.				
ARTHROPODA	* Hippolyte californiensis				
ARTHROPODA	* Hippolyte clarki				
ARTHROPODA	* Jassa falcata				
ARTHROPODA	* Lepas pacifica				
ARTHROPODA	* Lophopanopeus sp.				
ARTHROPODA	* Lysmata californica				
ARTHROPODA	* Loxorhynchus crispatus				
ARTHROPODA	* Pachygrapsus crassipes				
ARTHROPODA	* Paracerceis cordata				
ARTHROPODA	* Pentidotea resecata				
ARTHROPODA	* Pleustes platypa				
ARTHROPODA	* Pugettia producta				
ARTHROPODA	* Taliepus nuttali				
ENCHINODER	Amphiodia urtica			2	2
ENCHINODER	Amphipholis sp.				4
ENCHINODER	Astrometis sertulifera				2
ENCHINODER	Astropecten armatus			2	
ENCHINODER	Astropecten verrilli	4			
ENCHINODER	Centrostephanus coronatus	3			34
ENCHINODER	Dermasterias inbricata	2		234	2
ENCHINODER	Henricia leviuscula	2		234	3
ENCHINODER	Lissothuria nutriens		4	4	4
ENCHINODER	Lovenia cordiformis		2	2	
ENCHINODER	Lytechinus anamesus	2	234	234	234
ENCHINODER	Ophioderma panamense			4	4
ENCHINODER	Ophioderma papillosa		3		2
ENCHINODER	Ophioplocus esmarki			2	
ENCHINODER	Ophionereis annulata	4		4	
ENCHINODER	Ophiopteris papillosa			2	
ENCHINODER	Ophiothrix spiculata	24	24	34	24
ENCHINODER	Orthasterias koehleri			23	
ENCHINODER	Parastichopus parvimensis	34		34	34
ENCHINODER	Parastichopus spp.	2		2	2
ENCHINODER	Patiria miniata	23	23	234	23
ENCHINODER	Pisaster brevispinus	4	23	234	24
ENCHINODER	Pisaster giganteus	234	234	234	234
ENCHINODER	Pisaster ochraceus	2			
ENCHINODER	Strongylocentrotus franciscan	234	24	234	234
ENCHINODER	Strongylocentrotus purpuratus	4		24	234
ENCHINODER	Unidentified ophiuroidea	34	4	34	34
ENCHINODER	* Dendraster sp.				
ENCHINODER	* Eupentacta quinquesemita				

ENCHINODER	* Linkia columbiae				
ENCHINODER	* Ophiothrix rudis				
TUNICATA	Chelysoma producta		234	234	23
TUNICATA	Clavellina huntsmani	2			
TUNICATA	Cystodites lobatus	234	234	234	234
TUNICATA	Didemnum carnulentum	234	234	234	234
TUNICATA	Didemnidae	34	23	24	2
TUNICATA	Eudistoma diaphanes	4			
TUNICATA	Eudistoma psammion	24			
TUNICATA	Euherdmania claviformis	234	234	234	23
TUNICATA	Polyclinum planum		3		
TUNICATA	Pycnoclavella stanleyi	23			
TUNICATA	Pyura haustor	234		2	
TUNICATA	Styela montereyensis	234	234	234	23
TUNICATA	Tridemnum opacum	4	4	34	4
TUNICATA	Unidentified colonial	4	3		
TUNICATA	Unidentified solitary				4
TUNICATA	* Aplidium californicum				
TUNICATA	* Diplosoma macdonalid				
TUNICATA	* Styela truncata				
TUNICATA	* Styela plicata				
PISCES	Aetobatus californicus		4	4	
PISCES	Anisotremus davidsoni		01	014	23
PISCES	Arbaciosa rhessodon		2		
PISCES	Atherinid		01	0124	0124
PISCES	Brachyistius frenatus		01	012	01
PISCES	Chromis punctipinnis	234	01		
PISCES	Coryphopterus nicholsi	23		24	23
PISCES	Cynoscion nobilis		01	01	
PISCES	Damalichthys vacca	2	01	0123	0124
PISCES	Embiotoca jacksoni	34	013	23	24
PISCES	Gibbonsia elegans			4	
PISCES	Girella nigricans	24	01	014	01234
PISCES	Halichoeres semicinctus	4		01234	234
PISCES	Heterostichus rostratus		01	012	013
PISCES	Hypsypops rubicunda	4		3	3
PISCES	Medialuna californiensis	23	01	013	014
PISCES	Oxyjulis californicus	4	013	01234	01234
PISCES	Paralabrax clathratus	234	01234	01234	234
PISCES	Paralabrax nebulifer	234	234	01234	01234
PISCES	Phanerodon furcatus	3	012	01234	01
PISCES	Pimelometopon pulchrum	24	01	0124	24
PISCES	Pneumatophorus diego			4	
PISCES	Rhacochilus toxotes	3			4
PISCES	Scorpaena guttata			34	2
PISCES	Scorpaenichthys marmoratus	4			
PISCES	Sebastes atrovirens	3			
PISCES	Semicossyphus pulcher	3	3	3	3
PISCES	Sphyraena argentea		013	01	014

PISCES		Trachurus symmetricus		10	10	01
PISCES		Unidentified Cottidae			4	
PISCES		Unidentified turbot	2	3	4	
PISCES		Xenistius californiensis	3		0134	01
PISCES		Xystreurys liolepis			2	
		SOK UNITS 2 & 3				
PISCES	Imp	Alopia vulpinas		2		
PISCES	Imp	Amphistichus argenteus		24		
PISCES	Imp	Anchoa compressa		234		
PISCES	Imp	Anchoa delicatissima		34		
PISCES	Imp	Anisotremus davidsoni		234		
PISCES	Imp	Atherinops affinis		234		
PISCES	Imp	Atherinopsis californiensis		34		
PISCES	Imp	Atractoscion nobilis		24		
PISCES	Imp	Balistes polylepis		4		
PISCES	Imp	Brachyistius frenatus		234		
PISCES	Imp	Cheilotrema saturnum		234		
PISCES	Imp	Chilara taylori		234		
PISCES	Imp	Chromis punctipinnis		234		
PISCES	Imp	Citharichthys stigmaeus		234		
PISCES	Imp	Clupea herrengus		3		
PISCES	Imp	Cymatogaster aggregata		234		
PISCES	Imp	Damalichthys vacca		234		
PISCES	Imp	Dorosoma petenense		34		
PISCES	Imp	Embiotoca jacksoni		234		
PISCES	Imp	Engraulis mordax		234		
PISCES	Imp	Genyonemus lineatus		234		
PISCES	Imp	Gibbonsia elegans		4		
PISCES	Imp	Gibbonsia jenkensi		2		
PISCES	Imp	Gibbonsia metzi		24		
PISCES	Imp	Gibbonsia montereyensis		4		
PISCES	Imp	Gibbonsia sp.		4		
PISCES	Imp	Girella nigricans		34		
PISCES	Imp	Gobiidae		4		
PISCES	Imp	Gymnothorax mordax		234		
PISCES	Imp	Gymnura marmorata		34		
PISCES	Imp	Halichoeres semicinctus		234		
PISCES	Imp	Hermosilla azurea		234		
PISCES	Imp	Heterodontus francisci		34		
PISCES	Imp	Heterostichus rostratus		234		
PISCES	Imp	Hyperprosopon argenteum		234		
PISCES	Imp	Hypsoblennius gilberti		234		
PISCES	Imp	Hypsoblennius jenkinsi		2		
PISCES	Imp	Hypsoblennius spp.		34		
PISCES	Imp	Hypsopsetta guttulata		234		
PISCES	Imp	Hypsypops rubicundus		34		
PISCES	Imp	Leptocottus armatus		34		
PISCES	Imp	Leuresthes tenuis		234		
PISCES	Imp	Medialuna californiensis		234		
PISCES	Imp	Menticirrhus undulatus		234		

PISCES	Imp	Micrometrus minimus	23
PISCES	Imp	Mustelus californicus	4
PISCES	Imp	Mustelus henlei	24
PISCES	Imp	Myliobatis californica	34
PISCES	Imp	Neoclinus blanchardi	4
PISCES	Imp	Ophichtus zophochir	2
PISCES	Imp	Otophidium scrippsi	234
PISCES	Imp	Oxyjulis californica	23
PISCES	Imp	Paralabrax clathratus	234
PISCES	Imp	Paralabrax maculatofasciatus	34
PISCES	Imp	Paralabrax nebulifer	234
PISCES	Imp	Paralichthys californicus	234
PISCES	Imp	Peprilus simillimus	234
PISCES	Imp	Phanerodon furcatus	234
PISCES	Imp	Platyrhinoidis triseriata	34
PISCES	Imp	Pleuronichthys coenosus	234
PISCES	Imp	Pleuronichthys ritteri	234
PISCES	Imp	Pleuronichthys verticalis	34
PISCES	Imp	Porichthys myriaster	234
PISCES	Imp	Porichthys notatus	234
PISCES	Imp	Porichthys spp.	3
PISCES	Imp	Rhacochilus toxotes	234
PISCES	Imp	Rhinobatos productus	34
PISCES	Imp	Roncador stearnsi	234
PISCES	Imp	Sardinops sagax	4
PISCES	Imp	Scomber japonicus	34
PISCES	Imp	Scorpaena guttata	234
PISCES	Imp	Scorpaenichthys marmoratus	34
PISCES	Imp	Sebastes auriculatus	4
PISCES	Imp	Sebastes paucispinis	4
PISCES	Imp	Sebastes rastrelliger	34
PISCES	Imp	Sebastes sp.	24
PISCES	Imp	Semicossyphus pulchur	234
PISCES	Imp	Seriola dorsalis	4
PISCES	Imp	Seriphus politus	234
PISCES	Imp	Sphyraena argentea	34
PISCES	Imp	Squalus acanthias	23
PISCES	Imp	Squatina californica	4
PISCES	Imp	Syngnathus leptorhynchus	2
PISCES	Imp	Syngnathus spp.	234
PISCES	Imp	Synodus lucioceps	23
PISCES	Imp	Torpedo californica	34
PISCES	Imp	Trachurus symmetricus	34
PISCES	Imp	Umbrina roncador	234
PISCES	Imp	Urolophus halleri	234
PISCES	Imp	Xenistius californiensis	234
PISCES	Imp	Xystreurys liolepis	3
MAMMALIA		Zalophus californianus	23

APPENDIX 5

Techniques for establishing kelp beds

Numerous projects to establish new kelp beds or restore degraded kelp habitats have been undertaken in Southern California. Although the goals are not identical, the techniques used tend to be the same, and these are summarized in this appendix.

Most of the effort for establishing kelp beds has been devoted to transplant techniques. However, site selection and preparation are also important. One focus of site preparation has been the removal of dense growths of other species of brown algae, which could inhibit the recruitment of juvenile Macrocystis. A much more important focus, however, has been control of sea urchins (particularly Stongylocentrotus purpuratus and S. franciscanus). Before 1976, urchins on Palos Verdes were crushed by hammer-wielding divers. Hammering in the most selective and least complex method of urchin control, and is the most cost-effective method when urchins average less than $5/m^2$ (Wilson and McPeak 1983). Urchin control has also been accomplished by the use of quicklime (calcium oxide, CaO) to chemically destroy the urchins. Initially, quicklime was dispersed in pebble form from the surface of the water, but after 1976 a diver-operated device for dispersal allowed better control and greater efficiency. The most recent technological advance in urchin control, a diver-directed suction dredge, has been used by Kelco Company. Before using the suction

dredge, urchins are concentrated by baiting a location with a mesh bag filled with kelp; after a few days, urchins have aggregated around the bag, facilitating their removal by the dredge. Finally, a commercial sea urchin fishery has developed and, although it is unrelated to kelp transplantation efforts, in some situations it has contributed to the success of restoration projects.

An important aspect of many kelp restoration projects has been grazer control. The control of one important group of grazers, sea urchins, has been discussed above under site preparation. Fish grazing, particularly by the opaleye, Girella nigricans, and the halfmoon, Medialuna californiensis, can also cause considerable damage to transplanted kelp in Southern California. Although fish grazing was not a problem during restoration efforts at Point Loma, transplanted Macrocystis were apparently severely damaged at Palos Verdes. Fish traps and spearfishing were not effective control techniques. Gill nets captured large numbers of herbivorous fish, but also killed many nonherbivorous fish. Fish exclosures required excessive maintenance. Eventually, efforts to control fish grazing were abandoned (Wilson and McPeak 1983).

After site preparation, most projects have relied upon transplanting adult kelp plants (sporophytes) to establish a new bed. At Palos Verdes, two methods were used to attach the transplanted plants to the substrate (Wilson et al. 1979). Some plants were attached to floats, which were in turn attached to 2.5-3.1 cm anchor chains by 0.5 m nylon lines; holdfasts of plants attached with this technique were prepared by lacing nylon lines

through the haptera and tying the holdfast to floats. The preferred method of attachment, at least for smaller plants, was to secure the kelp plant directly to the substrate with inner tube circlets. Other methods for transplanting adults have been developed more recently, such as placing holdfasts in weighted mesh bags (Neushul and Harger 1985).

Another transplant technique has been developed for young Macrocystis plants that utilizes other vegetation. Young Macrocystis plants were secured to 7 cm high "stubs" of Pterygophora and Eisenia with rubberbands (Wilson and McPeak 1983). The Macrocystis plant was pushed to the base of the stub to minimize the distance the haptera had to grow to reach the substrate.

Although most kelp restoration projects have transplanted adult or juvenile Macrocystis plants, earlier life stages can also be utilized. North (1981) reports using embryonic Macrocystis sporophytes that had been grown in mass cultures to attempt to establish or restore kelp beds in Southern California. Many of the attempts to use cultured Macrocystis failed, but North attributed reappearance of kelp in a few instances to the influence of the sporophytes he dispersed. Neushul attempted to establish kelp on an artificial reef by spraying the reef boulders with a gametophyte solution before they were placed in the water (J. Benson, personal communication). Dean has been using outplants of gametophytes and microsporophytes, as well as juvenile plants (see Dean 1986). The microscopic sporophytes have been cultured on artificial rope

substrates in the laboratory before being outplanted into the field.

APPENDIX 6

Techniques for restoring coastal wetlands

(From Zedler, J., M. Josselyn and C. Onuf. 1982. Restoration techniques, research, and monitoring: Vegetation. In: M. Josselyn, ed. Wetland restoration and enhancement in California. Workshop Proceedings, California Sea Grant Collect Program Publication, Report No. T-CSGCP-007. pp. 73-74.

Restoration Techniques, Research, and Monitoring: Vegetation

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Introduction

Marsh vegetation provides a transition from aquatic to terrestrial habitats. To many people, wetlands symbolize a highly productive ecosystem which supports abundant wildlife; to others, they are wastelands suitable only for trash dumping or off-road vehicle use. Scientific study of California's marshes has provided further views of what these habitats are like, how they function in the total wetland ecosystem, and how some species might be established in attempts to restore or enhance disturbed habitats.

Our goals in this paper are to summarize the ecological features of wetland vegetation, review the data available on vegetation establishment in California wetlands, outline the ecological considerations which must be made in planning marsh establishment, and suggest research programs which are necessary to improve marsh restoration efforts. The paper discusses emergent and submerged vegetation, with emphasis on salt marshes, for which the most data exist. C. Onuf contributed information on eelgrass habitats; M. Josselyn summarized San Francisco Bay and northern California marshes; and J. Zedler summarized southern California marshes. We thank Fran Demgen, Tom Harvey, and John Oliver for their critical reviews of the manuscript.

Marsh Characteristics

Throughout California, wetland habitats are characterized by variable hydrologic regimes. Tidal marshes are regularly inundated and exposed. All marshes are subject to seasonal freshwater input, occasional heavy flooding, and long periods of exposure and evaporation. These extremes result in some conditions which are highly stressful and other conditions which are beneficial to and responsible for high plant productivity. For example, variable water levels may enhance or reduce plant growth, depending on the timing and duration of standing water/drought. Non-tidal marshes, which are subject to varying rainfall, river flow, and evaporation, may encounter the greatest extremes and the least predictable hydrologic regimes. Intertidal marshes experience regular cycles of inundation and exposure, which facilitate watering and drainage, but plants encounter the additional stresses of salinity. In coastal marshes of southern California, soil hypersalinity is a major stress for vascular plants. In addition, desiccation during periods of rain-free neap tides is stressful to soil algal mats. In central and northern California, hypersaline conditions can occur during summer months, but are restricted to the high marsh.

Soil salinity is a major controlling factor of both composition and productivity of marshes. Where soils are saline to hypersaline, a variety of halophytes, notably pickleweed and cordgrass, occur. Where soils are less saline to fresh, cattails, bulrushes, and sedges dominate and vascular plant productivity is higher. Throughout these marshes, soil algal mats develop when moisture and light permit. With a dense overstory, algal growth is light-limited; with a more open canopy, algal productivity can equal that of the vascular plants (Zedler 1980). Other factors which are known to influence marsh structure and function include microtopography, sediment type, and tidal regime (Table 1).

The basic function of marsh plants is primary productivity, however only a handful of productivity studies have been done in California (reviewed by Macdonald and Winfield unpubl.). Only one study examined algal productivity, and even the studies of vascular plant productivity are difficult to compare because of different measurement techniques. At present, it appears that California's coastal salt marshes are probably as productive as those on the East and Gulf of Mexico coasts, but that algal mats may play a more important role here, especially in hypersaline wetlands (Onuf *et al.* 1978, Winfield 1980, Zedler 1980). Export of organic matter from marshes to tidal creeks has been identified by Winfield (1980), but

Attribute	Southern California 32°-35°N Lat.	Central & Northern California 35°-43°N Lat.	San Francisco Bay 37°50'-38°20'N Lat.
Physiography	Narrow river valleys; small wetlands; tidal creeks & channels but few large embayments	Small wetlands on coast protected by sand dunes; gradual sloping marshes within embayments with variable occurrence of *Spartina foliosa*	Broad plains at MHHW traversed by deep sloughs; gradual slopes colonized by *Spartina foliosa* or precipitous margins undercutting high marsh
Precipitation and period of major surface runoff	10-30" winter	30-100" fall-winter-spring	20-40" winter-spring
Sediment type	Sandy sediments on coast, clays within embayments	Sandy sediments on coast, clays within embayments	Primarily clays
Salinity	Soils generally hypersaline all year	Northern marshes are generally near or below seawater salinity	Seasonally hypersaline
Vegetation dominants			
lower elevations (below MHW)	*Spartina foliosa* (variable occurrence) *Salicornia virginica* *Batis maritima* *Salicornia bigelovii* *Jaumea carnosa* *Suaeda californica* *Frankenia grandifolia* *Triglochin concinnum*	*Spartina foliosa* (variable occurrence) *Salicornia virginica* *Jaumea carnosa* *Frankenia grandifolia*	*Spartina foliosa* *Salicornia europaea* *Scirpus robustus* *Frankenia grandifolia* *Cuscuta salina* *Salicornia virginica* *Cotula coronopifolia* *Cordylanthus mollis*
higher elevations (above MHW)	*Monanthochloe littoralis* *Salicornia subterminalis* *Distichlis spicata*	*Triglochin maritima* *Spergularia marina* *Distichlis spicata* *Limonium californicum* *Atriplex patula ssp. hastata*	*Distichlis spicata* *Atriplex patula ssp. hastata*
Vascular plant productivity and canopy structure	Generally under 1 kg/m²/yr due to hypersaline soils; relatively open canopy	Ranges between 0.5-1.5 kg/m²/yr relatively dense canopy; higher rates in areas of freshwater input.	
Soil algal mat development	Often lush algal mats with very high productivity (at times equalling vascular plant productivity)	Dense macroalgal mats (*Enteromorpha*) in pannes and on mudflats adjacent to marsh; productivity exceeds that of marsh plants	Algal growth restricted to open pannes in marsh; limited growth on mudflats due to high turbidity
Herbivores and detritivores			
molluscs	*Cerithidea californica* *Melampus olivaceus* *Assiminea californica*	*Assiminea californica* *Ovatella myosotis*	*Nassarius obsoleta* *Modiolus demissus* *Macoma balthica*
amphipods	*Orchestoidea spp.*	*Orchestia traskiana* *Corophium spinicorne*	*Ampelisca milleri*
isopods			*Sphaeroma pentadon*
crabs	*Uca crenulata* *Pachygrapsus crassipes* *Hemigrapsus oregonensis*	*Hemigrapsus oregonensis*	*Hemigrapsus oregonensis*
fish	various species of fish use algae and detritus during parts of their life cycles		
Carnivores			
fish in saltmarsh channels	arrow gobies, killifish	arrow gobies, killifish	arrow gobies, killifish
birds frequenting saltmarsh vegetation	Belding's Savannah sparrow; light-footed clapper rail; willet, long-billed curlew, long-billed marsh wren, pintail, marsh hawk, Say's phoebe	willet, long-billed curlew, marbled godwit, great blue heron, snowy egret, common egret, California clapper rail, merlin	Samuel's song sparrow, Alameda song sparrow, California black rail, California clapper rail, salt marsh yellowthroat, great blue heron, great egret, American bittern
Rare and endangered species			
animals	California least tern Light-footed clapper rail Belding's Savannah sparrow American peregrine falcon	American peregrine falcon California least tern California clapper rail	Salt marsh harvest mouse California least tern California clapper rail San Francisco garter snake
plants	*Cordylanthus maritimus ssp. maritimus*	*Cordylanthus maritimus ssp. palustris*	*Cordylanthus maritimus ssp. mollis*

measurements by Onuf *et al.* (1978) did not provide strong support for a net export. Both studies concerned southern California coastal wetlands. Only limited estimates for fresh or brackish marsh productivity are available for California (Atwater *et al.* 1979).

Restoration Objectives

The objectives of wetland enhancement and restoration projects capitalize on high biological productivity. The most commonly stated objective is the preservation and creation of wildlife habitat. Wetlands serve as the major feeding areas to migratory birds along the Pacific flyway (Gertenberg 1979; Recher 1966) and as a nursery to many larval and juvenile fish (California Sea Grant 1981). Shelter is provided by vegetation, both as a direct habitat and in reducing waves, currents, and wind. Several species of birds are directly dependent on marsh vegetation, and habitat destruction has endangered several species (Table 1). A guiding mandate has been to protect and expand wetlands wherever possible (California Resources Agency 1977).

Disturbances (dredging, filling, and altering hydrologic and sedimentation cycles) have substantially modified California's remaining marsh habitats (Table 2), and "restoration" implies the goal of returning these systems to their pre-disturbance condition. Just how these disturbances have changed marshes is almost impossible to assess. We have no pristine marshes left with which to compare more disturbed habitats. Even if we knew what historical marsh conditions were, too additional facts make it impossible to reproduce those conditions. First, since the character of marshes is linked to their respective watersheds, restoration of a marsh would require restoration of the watershed as well—clearly an impractical, if not impossible, requirement. Second, marshes are dynamic communities, constantly changing in response to sedimentation, flooding, rising sea level, and other coastal processes. On a geologic time scale, their existence is short (usually measured in thousands of years), and it would be difficult and arbitrary to recreate a single stage in their development.

For what, then, should a marsh restoration project strive? What should be the "model community?" Clearly a plan for saltmarsh establishment or restoration will have to be based on generalized ecological information on what natural marshes were probably like, developed in conjunction with the management goals of the locality and of the region. An overview of saltmarsh vegetation is given by Macdonald (1977a, b) and Zedler (1982), and several marshes have been described individually by authors cited in Table 5. These papers should provide the starting point for attempts to restore or enhance coastal wetland plant communities. Much less information is available for California's inland marshes.

Table 1: *Comparison of saltmarsh characteristics for California wetlands. Coastal wetlands delimited by phytogeographic provinces from MacDonald (1977 a,b). Authorities for scientific names: plants—Munz (1959,68); invertebrates—Smith and Carlton (1975); and common names: birds—Cogswell (1977).*

At times, wetland creation has been promoted to perform tasks which might otherwise be too expensive or difficult to accomplish through other means. Dredge spoil disposal has become increasingly expensive due to reduced availability of disposal sites necessitating high transportation costs and the decontamination or control of polluted sediments. Wetland creation has provided the means to justify shallow aquatic and nearshore disposal and to stabilize the material. Microbiological processes in sediments colonized by marsh plants can lead to more permanent removal of heavy metals than otherwise economically possible (Windom 1977). The completion of the Dredged Material Research Program by the U.S. Army Corps of Engineers has led to several bookshelves of reports (Herner and Co. 1980) and a few dredgespoil wetlands have been created in California.

diking
filling
dredging
introduction of exotic species
reduced tidal flushing marsh becomes more saline than normal (in dry years) marsh becomes less saline than normal (in wet years)
toxins and fertilizers in runoff fertilizers may enhance vegetation toxins may stress vegetation
altered runoff patterns increasing flood flows decreasing flood flows constricting period of flooding prolonging period of flooding
altered sediment input increased sediment loads decreased sediment loads

Table 2: *Man-made disturbances to coastal marshes.*

In addition, marshes have potential for tertiary treatment of sewage effluent. Wetlands are frequently labeled as nutrient traps, though their ability to remove nutrients varies considerably (Valiela *et al.* 1978; Winfield 1980). Most pilot investigations have focused on freshwater wetlands (Sloey *et al.* 1978) and several projects have been completed and are under investigation in California (Bastian and Reed 1979). A freshwater-brackish water marsh has recently been proposed for San Francisco Bay using treated effluent (State Coast. Conserv. 1981). Future large scale marsh creation for sewage treatment will depend heavily on the results of these pilot projects to prove their effectiveness (SFRWQCB 1977).

These three "restoration goals" (restoring what has been degraded, turning dredge spoil deposits into wildlife habitat, and treating sewage effluent) each require the creation of appropriate marsh communities. Unfortunately we have insufficient background information on the past extent of specific marsh communities in California. We can provide only general guidance on what marsh types have been most altered and hence deserve greater consideration for restoration. Re-establishment of *Spartina foliosa* in southern California; removal of exotics such as *Avicennia* in Mission Bay marsh; and restoration of the transition zone habitat in San Francisco Bay deserve such attention. We have greater information on the habitat needs of certain wildlife species and such data should be included in restoration plans. The best data base concerns marsh plants which are utilized by water-related birds as food (e.g. widgeon grass, *Ruppia maritima;* alkali bulrush, *Scirpus robustus*) or cover (cordgrass, *Spartina foliosa*, for light-footed clapper rail nesting habitat; pickleweed, *Salicornia virginica*, nesting habitat for the Belding's Savannah sparrow, California clapper rail, and the black rail).

1. Maintain or expand the natural variety of habitats within the wetland. Design for heterogeneous topography and salinity regimes to create brackish and saltmarsh vegetation, pools, salt flats, and transitional areas.
2. Create habitats for endangered plants and animals. Usually involves establishing dominant plants such as cordgrass and pickleweed to support the endangered species within region. May also include creation of isolated upland and transitional plant communities.
3. Use of plant communities to improve water quality. Improve tidal flushing into restricted areas and/or use of treated effluent to increase water flow and effluent quality.
4. Creation of vegetated corridors to facilitate movement of animals between isolated wetlands.
5. Planting of vegetation to reduce shoreline erosion and stabilize dredge spoil.

Table 3: *General goals given for vegetation establishment when enhancing or restoring wetlands.*

Table 3 summarizes a number of general goals which have been given for previous marsh restoration projects. Basically, the overall plan has been to recreate tidally flushed wetlands with more species or a more diverse assemblage of species than currently exists. Since one site will probably not meet all of the restoration objectives for a region, (*i.e.* habitat for various endangered species such as least terns, light-footed and California clapper rails, various salt marsh sparrows, and harvest mice), and wildlife using coastal marshes migrate from one to another and utilize the collective assets of these wetlands, planning for marsh restoration projects should be coordinated within the region, if not within the state. Objectives which cannot be met within one site may be given higher priority for another.

- modification of hydrological regime
  - provide tidal flow
  - alter channels and creeks
  - control freshwater runoff (increase or decrease)
- provide suitable habitat for vegetation establishment
  - establish appropriate elevations with dredge spoils
  - contour topography to proper elevation & slope
  - cage out herbivores
  - stabilize soil
  - irrigate to reduce salinity
- augment natural vegetation establishment with plantings

Table 4: *Techniques used to enhance plant habitats in marshes.*

Marsh Restoration Techniques

The techniques used to meet the above objectives include modifying water circulation, establishing new substrate elevations, and planting (Table 4). Removal of man-made levees and dikes has been the most frequently used method to restore tidal flow; however, channel excavation may also be required to reduce mosquito problems. Discharge of treated sewage effluent to create a diversified wetland habitat is an important alternative to dike breaching, but is subject to water quality and public health constraints. Providing suitable elevations for the establishment of wetland vegetation in restorations has proven to be difficult from an engineering standpoint. Excess disposal of dredge spoils has resulted in numerous "marshes" with elevations above normal tidal influence (Josselyn and Atwater 1982). Excavation of channels and earthmoving within the restoration prior to dike breaching have been used to establish specific elevations and habitats, but can be quite costly compared to other restoration techniques. Planting of marsh vegetation, particularly *Spartina foliosa*, has been tested under a variety of conditions in California and is reviewed in Table 5. On the other hand, natural establishment of marsh vegetation following habitat creation has been followed in several marshes. At a restoration in northern San Francisco Bay, Faber (1980) reported that natural establishment of pickleweed and cordgrass was greatest between the third and fourth year of the restoration. Pickleweed, however, spread far more rapidly than cordgrass and comprised over 95 percent of the biomass by the fourth year. In

Topic	General	Southern Cal	Central and Northern Cal	San Francisco Bay
1. Plant community description for selection of appropriate species	Macdonald (1977a,b) Cal Fish and Game (1970-78) Harvey *et al.* (1976)	Zedler (1982) Vogl (1966) Macdonald (1967) Purer (1942) Zedler (1977) Massey & Zembal (1979) Warme (1969)	MacGinitie (1935) Proctor *et al.* (1980) Shapiro and Assoc. (1979)	Mahall and Park (1976) Atwater and Hedel (1976) Atwater *et al.* (1979) Hinde (1954) Mall (1969)
2. Conceptual planning and methods of site preparation	Garbisch (1977) Woodhouse (1979) Envir. Lab. (1978) Johnson and McGuinness (1975)	Smith *et al.* (1975) Firle and Smith (1977) Sorensen, unpubl.	Terrascan (1979) Camp, Dresser, and McKee, and Madrone Assoc. (1980)	Harvey *et al.* (1982)
3. Endangered species habitat needs	Cal Fish and Game (1974)	Massey (1979) Fox and Knudsen (1981) Dunn (1981) Massey and Zembal (1979) Zembal and Massey (1981)		Shellhammer and Harvey, unpubl. Jones and Stokes (1979)
4. Wastewater treatment projects	Tchobanoglous and Culp (1980) Demgen (1981)	Gearheart and Finney (1981)		Demgen (1979) Cederquist and Roche (1979)
5. Vegetation establishment including propagule selection, storage and handling, planting techniques, and natural recolonization	Envir. Lab. (1978) Maguire and Heuterman (1978) Kadlec and Wentz (1974)	Zedler (1980, 1981a, 1981b) Zedler *et al.* (1979) Nordby *et al.* (1980)	Oliver and Reilly (1981)	Newcombe and Pride (1976) Harvey *et al.* (1982) Niesen and Josselyn (1981) Mason (1980)
6. Substrate requirements of vegetation	Garbisch (1977) Envir. Lab. (1978)			Harvey *et al.* (1982)
7. Costs and maintenance requirements	Envir. Lab. (1978)		Terrascan (1979) Camp, Dresser, and McKee, and Madrone Assoc. (1980)	US Army Corps (1976) Josselyn and Atwater (1982)

Table 5: *Recent literature on vegetation establishment for California coastal and estuarine wetland restorations.*

southern San Francisco Bay sparse stands of pickleweed were observed in the Hayward restoration within the first year, but even after two years, no cordgrass had invaded despite extensive areas of suitable elevation (Josselyn and Perez 1981). Relatively high soil salinities may inhibit seed germination at this site which was formerly a salt evaporator. Soil salinity plays an important role in regulating rates of natural plant establishment and vegetative spread in southern California as well (Zedler 1981b). Regardless of the techniques used, the examples are too few, and their period of existence too short to provide an instructional guide for marsh restoration in California. At present, restoration must be viewed as experimental.

However, in the process of performing these studies, a number of limiting factors have been revealed (Table 6) and future projects should focus on overcoming these obstacles. The problems range from environmental stresses (wave force, subsidence, hypersalinity) to biological restraints (competition with other species, herbivory).

Submerged Seagrasses

Recent reviews of the vast literature of seagrass ecosystems (Phillips and McRoy 1980, McRoy and Helfferich 1977, Thayer *et al.* 1975) summarize the characteristics of eelgrass beds and list the values that argue for their incorporation in coastal wetland restoration projects. Some of them are as follows:

1. Primary production is very high. Based on the difference between maximum and minimum standing crops sampled during a year, eelgrass productivity in South and North Humboldt Bay was 590 and

Attribute	Southern California	Northern California Central California	San Francisco Bay
Source of vegetation propagules	limited area of marshes; most is protected as endangered species habitat	isolated wetlands; sources limited	sources usually readily available throughout Bay; seed sources limited for cordgrass
Seed production & seedling production	seeds are abundant for cordgrass & pickleweed, but germination rates are low; collection of seeds disturb marsh vegetation which is susceptible to trampling natural reproduction predominantly vegetative	cordgrass not found at all locations; pickleweed abundant	cordgrass seeds available in specific areas, collections should take place in Oct.; pickleweed seeds readily available natural reproduction by seed in fresher portion of estuary; otherwise vegetative
Site characteristics	bare soils are often extremely hypersaline (over 100 ppt) due to evaporation tidal flushing is often reduced by sand bars wave force is problem on exposed shores	watershed disrupted by upstream activities causing increased sedimentation/pollution some areas restricted by dikes	tidal flow restricted by dikes; subsidence of land due to groundwater withdrawal and soil erosion requires fill or tidal gate control to support wetland vegetation salt ponds create hypersaline soils which require leaching
Animal pests	pose a major problem, especially in areas near urban centers; ground squirrels and some birds seem to be the major problem		introduced invertebrate: *Sphaeroma* undercuts pickleweed marsh; need erosional control while cordgrass becoming established
Competition with more opportunistic species	pickleweed is the best natural invader, but cordgrass is often preferred for marsh enhancement because it supports light-footed clapper rails; pickleweed reduces survival, vegetative propagation of cordgrass	*Jaumea* invades rapidly, but is ultimately replaced by pickleweed	potential for escaped exotics to colonize upland areas and islands; potential for exotic species of cordgrass to invade native habitat cattails, tules, water hyacinth may take over freshwater marshes

Table 6: *Factors limiting the success of vegetation establishment in California wetland restorations.*

240 g dry wt/m²/yr respectively (Harding and Butler 1979).

2. Natural systems may filter sewage effluent. "In at least one recorded instance in Australia the efficacy of a *Zostera* meadow to filter raw sewage was established when the removal of the plants led to the poisoning of valuable benthos" (Phillips and McRoy 1980, p.300).

3. Coastal stabilization can be brought about by eelgrass. Drastic changes in coastal topography were observed in England and Denmark in the aftermath of the eelgrass "wasting disease" in the 1930's. Sandy beaches landward from eelgrass beds were replaced by cobble shores and bare muds (McRoy and Helfferich 1977, pp. 23-28).

4. The density and biomass of animals are much higher within and in the vicinity of eelgrass beds than away from the beds in the same general area and in the same depths (Orth 1977, Thayer *et al.* 1975). "We know that there are many reasons for the presence of animals in seagrass beds: the environment is more stable, since seagrasses hold sediments, baffle currents, provide shade and concomitant temperature modification. Also, there is as much as 20 times more surface area for small sessile flora and fauna as compared to unvegetated area. There are more hiding places for prey and thus more prey for predators to eat" (Phillips and McRoy 1980, p.322).

5. Ecological efficiency (ratio of the production of consumers to the amount that they consume) is high.

Habitat Factors	Vegetative Growth	Comments
Temperature		
Range	0-40°C	Probably not a constraint, since native populations exist along the whole coast of the state.
Optimum	10-20°	
Salinity		
Range	Freshwater–42 o/oo	
Optimum	10-30 o/oo	
Depth-Light		
Range	1.8 meters above MLLW to 30 meters deep	Light attenuation because of turbidity is likely to raise the lower limit considerably. Backman and Barilotti (1976) showed that light intensity determined the density and biomass of eelgrass at Agua Hedionda. Under ambient conditions, the lower limit was −2.5 to −3.0 (MLLW). In San Diego Bay a transplant at −1.5 to −1.8 m (MLLW) failed (Goforth and Peeling 1980).
Optimum	MLLW—6.6 m below MLLW (11 m at high tide)	
Substrate		
Range	Pure firm sand to pure soft mud	Apparently a reducing environment for the roots and an oxidizing environment for the leaves is necessary (Phillips 1974, pp. 255-258). Onuf's observations at Mugu Lagoon suggest that newly deposited unconsolidated muds are unsuitable. Transplants in coarser sediments performed better in San Diego Bay (Goforth and Peeling 1980).
pH	7.3-9.0	
Water Motion		
Range	Waves to stagnant water	May limit the development of eelgrass beds along the downwind side of shallow embayments with fine textured bottoms
Optimum	Little wave action. Gentle currents to 3.5 knots	

Table 7: *Environmental characteristics under which eelgrass grows (adapted from Phillips 1974, p. 260) with comments about application to coastal wetland restorations in California.*

"Our comparatively high efficiencies suggest that this eelgrass bed is an efficient system that provides resident fish with superior shelter, food, and protection... These fishes therefore would spend proportionately less of their assimilated energy coping with environmental extremes, searching for food, and escaping from predators, and hence may use a great proportion of consumed energy for growth and production" (Thayer *et al.* 1975).

6. At least for fishes, eelgrass is the most distinctive habitat of our coastal wetlands. The only clear habitat specialists encountered in five years of sampling at Mugu Lagoon are bay pipefish, *Syngnathus petorhynchus*, and shiner surfperch, *Cymatogaster aggregatus*, both only caught in eelgrass areas (Onuf and Quammen unpubl.). The eelgrass station yielded by far the biggest catches and largest number of species, until the eelgrass was destroyed by storm-caused sedimentation in 1978.

Where feasible, there are good reasons for incorporating eelgrass beds into future restoration projects. Unfortunately, information on how to accomplish this objective is inadequate. The published tolerance ranges of eelgrass for a variety of presumably important environmental factors provide a point of departure (Table 7); however, it is important to note that *Zostera marina* almost certainly is composed of different geographic stocks, with narrower ranges than indicated for the species (McRoy and Helfferich 1977, pp. 13-20, Phillips and McRoy 190, pp. 51-52).

Seagrass Restoration

Techniques for transplanting and culturing seagrasses are presented in Phillips and McRoy (1980) pp. 41-56 and 57-68, respectively. "Vegetative seagrass material gives an instant seagrass meadow when planted by sods, but sods are difficult to ship over large distances in the masses needed. Seeds are easy to transport in great masses, but the number of fruits and seeds produced per year is unpredictable and variable, seed germination rates can be low and unpredictable, many seeds appear to be lost in the field, and seedling survival appears to be low."

Planning the Nature of the Restoration	
Map of existing site	topography
	vegetation mapped to indicate pockets of desirable species
	soil properties; e.g. salinities, pH, heavy metals, pollutants soil structure as required by site location
Conceptual plan	attempt to resolve the local and regional restoration goals in conjunction with restrictions of the site
	determination of desired vegetation habitat size, based on wildlife need and vector control considerations. (Lack of information on a number of important research questions limits the recommendations that can be made at this time, research needs are on Table 10)
	ecosystem level management is preferred over single species management
	plan should built on existing assets of the site
Development of site plan	engineering sketches for establishing appropriate elevations, slopes, channels, and dike breeches
	consideration of local sedimentation problems and provision for protection of newly establishing plants from strong wave action

Undertaking Plant Establishment Following Site Preparation	
Map of Site	soil salinities, other soil properties appropriate to the site, i.e. pH; heavy metals, pollutants) hydrological features (e.g. wave force), and elevation 20 cm contours, if possible
Establishment test plantings	an intermediate area where on-site propagation of plants can occur. This is needed for large restoration sites or wherever propagules are limited in number. It should be located in the most favorable environment for rapid reproduction.
Detailed description of planting scheme	elevations determined for each species by reference to best information for the region
	timing specified: transplantation to occur during most favorable time of year (following rainfall but after flooding)
	protection devices provided against herbivores and wave force
	watering, if necessary
	type of materials to be planted (seed, sprig, core)
Monitoring program	details considered in Table 9
Plans for informaton dissemination	deposit findings in a central library

Table 8: *Recommended procedure for the establishment of vegetation in a wetland restoration plan.*

"Until methods are developed to initiate flowering in culture, with subsequent production of fruits and seeds, I recommend the plug" (plants with sediment intact placed in hole in substrate, 300 cm^2 x 15 cm deep) "as the single most important method of transplantation for mass-scale use... It would not be difficult to transport plugs in plastic sleeves or to hold them in such sleeves for later transplantation. It would not take as many plugs to 'patch' in a site as would sods." (Phillips and McRoy 1980, p.54).

Literature on the feasibility of eelgrass transplantation has been evaluated (Boone and Hoeppel 1976); field tests of techniques have been performed (Robilliard and Porter 1976); and two major transplants have been carried out and monitored in San Diego Bay (Goforth and Peeling 1980). Plugs of 410 cm^2 in fiber pots were set out at intervals of 0.6 m in rows that were 2 m apart. The intertidal transplant was successful; however, only the transplants on hummocks survived subtidally (-1.5 to -1.8 m MLLW) with the red alga *Gracilaria* dominating most of the site, presumably because of low light.

Restoration Plan and Project Monitoring

Once the goals of the restoration have been identified, the conditions of the site have been determined, and the constraints of materials and modifications are known, a specific implementation plan can be developed (Table 8). Because wetland restoration is still in its infancy, it is important that each project be recognized as an experiment and that the plan include monitoring of the site

before and after implementation in order to assess the success of the effort. This type of interaction between planning and evaluation of results has been called "adaptive management" by Walters and Hilborn (1978) of the University of British Columbia, and interaction is essential to move marsh restoration from the experimental phase to the desired "state-of-the-art". Specifics for planting schedules and methods have been developed for many Atlantic and Gulf coast marsh plants (Environmental Laboratory 1978). Most of the information available for West Coast species has been taken from plantings on dredge spoils in San Francisco Bay (Newcombe and Pride 1976). Unfortunately, long term study of these plantings has not been conducted on a consistent basis (Hanley Smith pers. comm.). As a result, planting techniques for West Coast species are often based on unpublished observations of consultants or scientists. Zedler (in prep.) and Josselyn (in prep.) are developing guidebooks for vegetation establishment for Southern California and San Francisco Bay, respectively, based on relatively long-term research.

An important consideration in any marsh restoration plan is knowledge of both elevations and soil characteristics at the site. Although we often know the tolerances of the species desired, the diverse methods and terminologies used to measure these environmental parameters lead to confusion among planners and scientists. For example, the tidal datum used as a reference level differs among civil engineers, scientists, and geologists. The National Geodetic Vertical Datum of 1929 (NGVD) has been suggested as the common reference datum for wetland scientists (H.T. Harvey these proceedings). Likewise, similar agreement is needed on methodologies and units to describe wetland soil characteristics (K. Cunio these proceedings). Future workshops should consider and adopt a consistent set of measurements to describe West Coast wetland environments.

Monitoring efforts must be sufficient to determine what caused the successes or failures of project components. "Failures" to achieve project objectives may then be mitigated by improved knowledge of how to succeed in future attempts. Were problems caused by site characteristics or planting techniques? Which characteristics or techniques were to blame? Setting up the project in an experimental framework would help to assess these causes. Preliminary small scale experiments could reduce implementation costs. For example, if soil salinities are very high, the plantings could be watered in some locations and not in others. Improved establishment where watered would indicate that drier, saltier soils restricted plant growth and that irrigation is necessary on the site.

A minimal monitoring plan is proposed in Table 9. Aerial photos can be most useful in following the establishment of vegetation and the spread of plantings. Aerial photos can also be used to map developing channels and areas of sedimentation or erosion. Both black and white and infrared photos should be taken. In most cases, planting should be delayed from six to twelve months so that sediments can reach equilibrium with the overlying water. This settling period can also be used to monitor naturally establishing plants and to assess their survival and growth. If planting is deemed necessary, several test plots should be established to develop recommendations for the complete planting program. Of course, the monitoring program should be expanded at restorations involving new site preparation techniques or in areas where no previous restorations have been completed or investigated.

1. aerial photos
   immediately following construction; yearly intervals afterwards done in spring.
2. establishment of permanent transects; sample at various elevations and flow regimes.
   a. soil survey at surface and 15 cm depth; salinity, pH, particle size, heavy metal/pollutants (as required by site)
   b. plant cover analyses and species composition: every six months (late summer; early spring) until marsh establishment is proceeding as expected
   c. sedimentation/erosion studies to assess long-term stability of site and possible corrective management practices
3. planting program: initiate six months to one year following construction activity.
   a. establish test plots at various elevations using natural plant volunteers as indication of planting sites
   b. evaluate growth of plants using expansion in diameter of clumps or number of stems
   c. develop complete planting program after initial results
   d. comparison with unplanted sites undergoing natural colonization

Table 9: *Recommendations for monitoring the establishment of vegetation in wetland restorations in California.*

Costs for monitoring should be included in the overall project and responsibility for evaluating the results of monitoring should be clearly identified. There is definitely a role for scientists in the process. Evaluation of management experiments could well be part of an ongoing scientific study of wetland functioning, although the monitoring alone would not likely be fundable by a research granting agency. Managers should seek the cooperation of researchers in all phases of the projects, from planning to final evaluation, to determine what aspects

Table 10: *Research recommendations toward improving the design of wetland restorations in California*

Determination of optimal habitat size and configuration (e.g. pickleweed and cordgrass marsh) for wildlife utilization. Patch size necessary to attract and support native animal populations; necessary buffer zone width and type; sensitivity of various animal species to disturbance; desired location of developments adjacent to wetlands; and types of structures and activities tolerated by wetland animals.
Requirements of marsh vegetation for tidal flushing and preferred balance of fresh and salt water influence. For wetlands which must be closed to tidal influence during certain periods (e.g. flooding of neaby streams), how long can tidal circulation be absent and not jeopardize the marsh? For marshes where freshwater flooding can be regulated, or where wastewater input can be added, what is the maximum allowable freshwater input for maintenance of brackish or saline marshes?
Impacts of nutrients on marshes and the use of treated wastewater to create fresh/brackish marsh areas. What are the desirable levels of nutrients in coastal marshes? How effective are marshes in removing nutrients from sewage effluent?
Comparisons between natural rates of vegetation colonization with the establishment of vegetation following artificial transplantation. How much faster do marshes establish with planting? Which species are in greatest need of transplantation because of biological limitations?
Relationship between vegetation density and mosquito vector control. What is the optimal density of vegetation (usable by wildlife such as rails) that can still allow vector control, and how can it be maintained?

are compatible with existing research projects. Habitat enhancement needs of the U.S. Navy, U.S. Fish and Wildlife Service and the Unified Port of San Diego have been partially met through cooperation with researchers funded by the California Sea Grant Program (Zedler).

The results of the monitoring must be readily available to be useful to future restoration projects. A central depository with funds to keep and disseminate these reports is needed. We suggest that the two estuarine sanctuaries in California, Elkhorn Slough and Tijuana Estuary, be funded to establish this service.

Quoting from Walters and Hilborn (1978, p. 183):

> *When we can . . . learn to treat . . . the whole management process as fundamentally experimental activities requiring active planning and judgment, then we may begin to talk about a* science *of ecological management.*

Suggestions for Future Research

Whenever possible, research should be undertaken to address questions beyond simple environmental monitoring (Table 10). Resolving some of these questions will improve the wildlife habitats created; answers to others are necessary to protect public health and meet state water quality standards. Of course, it will be difficult to set precise standards on the functioning of a wetland given its inherent variability and the degree of compromise needed to meet the demands of modern society. In addition, restoration and enhancement efforts should not take the single-species-management approach; instead we must manage for the entire ecosystem. Inter-relationships among wetland species are numerous, and altering one species will have impacts on many others. Research is our only tool to establish these relationships and to determine the optimal design and management procedures to protect wildlife and provide the public with the environmental quality they desire.

Panel Discussion

John Oliver, *Moss Landing, CA:*

My first comment is that the problems involving marsh restoration are primarily social and political and, therefore, economic. These issues were addressed in yesterday's sessions. The biological and physical problems are not difficult to overcome, but are intriguing.

I also want to emphasize the often neglected reality that nature is variable. We have management schemes and legal systems that are commonly invariant. Thus, while nature and our understanding of nature vary, our management and regulatory efforts are commonly inflexible and static. This is a tricky situation. I hope that realistic and useful management programs can be founded on these simple realities.

Another important point is that all marsh restoration or development projects are relatively large-scale experiments. Realizing the experimental nature of these activities will help in at least two ways. First, we can take advantage of the experimental setting to test relevant ideas and further our understanding of wetland communities, either for relatively applied or less applied goals. Second, a clear understanding of the experimental nature of these activities will help all parties to maintain an open mind about the entire process.

I want to make a few comments about monitoring. There is no distinct dichotomy between a monitoring activity and research, at least in most ecological monitoring efforts. Monitoring programs are generally used in a

more applied research activity. Very little monitoring of biological phenomena is useful for short-term surveillance or "bell ringing". Bacteria counts around a waste outfall may be the only exception, for better or worse. We carry on remarkable monitoring programs that are advertised as regulatory efforts and not research. Commonly they are actually concerned with large-scale or long-term changes which are very relevant applied science problems. But just as commonly the relationship between the monitoring activities and the applied research problem has not been clearly formulated or even recognized. In fact, when one attempts to match relevant questions to the monitoring activities, we often find that the question already has a good answer, that the activity is inappropriate to the question of concern, or that the question cannot be answered. I am convinced that most of the surveillance monitoring of biological events is useless and that a clear focus on applied research questions is essential to any monitoring activity.

H. Thomas Harvey, *San Jose State University, San Jose, CA:*

I do feel that we need monitoring to find out what we'd hoped for has to some degree been successful. I think that's been a part that hasn't been either reported or encouraged to the degree that it should have been. But I would like to get to some nitty-gritties and inasmuch as there is a captive audience, I will get on my soap box that some of you have endured before

First, we should start using NGVD for the Land Elevation Datum—and how it relates properly to tidal elevations, which are entirely something else. The current useage of various tidal elevations as reference for marsh development has resulted in considerable confusion among engineers, scientists, and agency people. Second, I think I should mention that if there is anything that's lacking in the paper, it's some specifics. Admittedly, there is tremendous variety throughout California.

I tend to side with some of you who believe that if you set up the physical conditions you should step back and get out of the way. Nature in the long run is going to decide which vegetation will survive under the circumstances that are present. I realize we can manipulate, to a certain degree, and we probably should, if we want certain things. But I think one of the main ingredients in marsh restoration is patience. Those of us who have been around awhile have had to learn that you can't plan it all. We have to just take what comes sometimes.

I would close only by suggesting that we recognize that humankind is probably more of a rationalizing organism than a rational organism. We have our gut reactions, opinions, and desires. We, then, marshal all the facts and evidence that will support those points of view. We are very good at that. So take that to mind, as well as, perhaps, to heart.

Fran Demgen, *Demgen Aquatic Biology, Vallejo, CA:*

I want to make one minor correction. If you look at the data you might get the wrong impression that the Mt. View Sanitary District enhancement was created to treat waste water. It's purpose is wildlife habitat creation.

The paper is very good in providing an overview. I think that what is missing are more specific facts, like the one given that one sprig in three years could develop an eight meter wide patch of grass. I think that even the range between complete failure and an eight-meter patch in three years is valuable to the people trying to do things. And I think that this paper would be a very valuable place to have specific data so that the people designing and doing projects have something to use as guidelines. Even if it's bad news, it's better than no news at all. There is a need to provide site-specific information, so that planners can interpolate and use the data in making their own conclusions. Many people are afraid of trying to tell other people what they've done, or applying their conclusions to other things, but I think this would be an important addition.

It seems like—and I didn't realize it originally—the major thrust here has been salt marshes and hopefully there will be more people that will also allude to freshwater systems, particularly those using waste water. It's very encouraging and heartening for me that so many other people have mentioned waste water wetlands. As few as about six years ago, you'd bring up waste water wetlands and people would look at you askance and wonder what on earth you were talking about. The two things are not incompatible and there are quite a few projects in existence now and others are planned.

One will be the big East Bay Regional Park-East Bay Dischargers Project that will be adjacent to our field trip site tomorrow. It's approximately 162 acres and will be a good opportunity to gain new information, processes that happen in these waste water marshes. Another project that should be happening this year is in Eureka, a 60-acre site. The City of Eureka will be restoring wetlands to the Elk River, including a certain amount of marsh using waste water. It will also include some that's returned to tidal action and some freshwater areas. There are, in addition, some seasonal ponds on that site making it a multi-habitat site. If everybody crosses their fingers in unison in this room, we may be able to get some water for the New Chicago Marsh down in the South Bay. We are working on possibilities of getting close to ten million gallons a day of treated effluent from San Jose, which is adjacent to the San Francisco Bay Wildlife Refuge and the water needy New Chicago Marsh.

Audience Participation

KATHERINE CUNEO (Madrone Associates): **I would like to make a suggestion. At the same time we form the depository of information, we should have a committee to work on the standardization of measurements used in published papers. Considering salinity, we find it is reported as molarity, as milliosmoles, as osmolarity in terms of pressure bars, and atmospheric pressure. We should have a method of transposing these to one standardized measure that planners could use. I suggest that on this committee we have a soils scientist, a plant physiologist, a wildlife biologist, a hydrologist, and a planner.**

DR. ZEDLER: Good suggestion.

WAYNE TYSON (Regrowth Associates): **What research is available on the reproductive biology of marshland plant species?**

DR. HARVEY: It's controversial and scattered. Some information is available from the Army Corps of Engineers.

RICHARD WARNER (Field Study Center in Davis): **Just a general comment to the panel at large and I mean this in a kindly, if critical way. I would suggest that we have failed rather thoroughly in the second half of our charge for this panel and that is to address the needs and opportunities for monitoring. The use of monitoring as separate and dichotomous from research in our American frame of reference is looked on with some humor by European scientists. They look at us in this context as a bunch of dilettantes jumping in and doing brilliant research for a couple of years and then rushing off to do equally brilliant research elsewhere with very little follow-through and exploitation of the cumulative empirical data base from our studies. And rarely, if ever, are we using the continued frame of reference of a growing data base to modify and even learn from our research efforts. Maybe the panel may have some comments about something that is germinating at the present time, but I presently see no plan for the required institutionalization of this data base.**

DR. ZEDLER: The National Science Foundation has just begun a long-term ecological research program. We've been nagging at Sea Grant to do something similar for a number of years. But I can't say that anything is germinating yet. A lot of seeds have been sewn.

DR. ONUF: I wrote a proposal to Sea Grant that was essentially aimed at this area you have pointed out. Maybe the institutions aren't ready for it yet, or the way I wrote it didn't get it across properly, but I met with a resounding lack of interest.

I think restoration is often regarded as a sell out to development. There are examples of failed restoration projects, where the trade-offs that were made can be shown, after the fact to have not been in the best interest of the natural systems concerned. There is, I think, a legitimate concern that restoration, as a mitigation, can be abused in the management system. And so there is this legitimate resistance to really making it a much more viable activity, until it can be shown to do the job.

The problem is we don't have the luxury in California of just leaving things alone and preserving what we have got. Because of what goes on in watersheds, wetlands will disappear if they are left alone. We have to get in and be heavy-handed. I'm trying, and obviously others of us are, too, but I think there is enough sales resistance that it's going to be a little while longer before we are going to get some systematic system of evaluation.

VIRGINIA RATH (Stanford University): **We have seen yesterday that there is often an absence of clear goals in what we are trying to accomplish by these restorations. And it seems that often we move towards assuming that the maximum species diversity is what should be sought for in these restorations.**

Dr. Zedler mentioned that pickleweed is often a superior competitor, even to the detriment of other species such as *Spartina* or other succulents. Often times, we have *Salcornia* marshes coming in even though we have planted *Spartina* as in the Faber Tract in San Francisco Bay.

Why all the push to plant *Spartina* here on the west coast when *Spartina* is often just fringing vegetation and the bulk of the marshes contain *Salcornia*. Is this another example of trying to get East Coast technology and East Coast dogma and plant it on the West Coast?

DR. HARVEY: The reason I was planting cordgrass at Faber Tract was to find out what the tidal elevation was. I wasn't trying to emulate East Coast marshes. I didn't know about them in '69 and '70. Anza Pacific is planted at about two feet above mean low or low water in an attempt to see what transplant procedures, seeds, seedlings, dwarf versus robust would survive under that end of the range.

MS. RATH: It's obvious many experimental pieces of information could come from these plantings. However, it seems that we persist in trying to plant *Spartina* marshes.

DR. HARVEY: That's why I made the comment about patience sometimes as your best approach. But cordgrass can and probably should be planted in certain places where you want to establish vegetation at the lower elevational range rapidly. Faber Tract is one of the longest duration. Cordgrass has spread throughout that 95 acres, although it's predominantly pickleweed, I agree.

DR. JOSSELYN: In Southern California, the reason there's been emphasis on cordgrass is that it is the habitat for the light-footed clapper rail and also the habitat that has been destroyed most frequently through development activity.

In San Francisco Bay, I agree that the pickleweed marshes do represent the pristine condition. Pickleweed is a great volunteer, it comes in very rapidly. Cordgrass, however, is very slow to colonize and some activity often is required in order to establish it.

GLOSSARY

Compensation - full replacement of project-induced losses to fish and wildlife resources (FWS Mitigation Policy)

Ecosystem - all of the biotic elements (i.e., species, populations, and communities) and abiotic elements (i.e., land, air, water, energy) interacting in a given geographical area so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles. (From E.P. Odum. 1971. Fundamentals of Ecology. Adopted by FWS)

Enhancement - the restoration or modification of part of an ecosystem that results in a net gain in resource value.

Evaluation species - those fish and wildlife resources in the planning area that are selected for impact analysis. They must currently be present or known to occur in the planning area during at least one stage of their life history (for exceptions, see FWS Mitigation Policy). Evaluation species are selected because (1) they have high public interest, economic value, or both; or (2) they provide a broader ecological perspective of an area. Species should be selected to represent social, economic and broad ecological views because mitigation planning efforts incorporate objectives that have social, economic, and ecological aspects. (From FWS Mitigation Policy)

Fish and wildlife resources - birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent. (From FWS Mitigation Policy)

Habitat - the area that provides direct support for a given species, population, or community, including air quality, water quality, vegetation and soil characteristics and water supply (From FWS Mitigation Policy)

Habitat value - the suitability of an area to support a given evaluation species (FWS Mitigation Policy)

In-kind replacement - providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost. (FWS Mitigation Policy)

Loss - a change in fish and wildlife resources due to human activities that is considered adverse and: (1) reduces the biological value of that habitat for evaluation species; (2)

reduces population numbers of evaluation species; (3) increases population numbers of "nuisance" species; (4) reduces the human use of those fish and wildlife resources; or (5) disrupts ecosystem structure and function. (FWS Mitigation Policy)

Minimize - to reduce to the smallest practicable amount or degree (FWS Mitigation Policy)

Mitigation - "(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments." (National Environmental Policy Act)

Mitigation banking - habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable losses from specific future development actions. (FWS Mitigation Policy)

Off-site - occurring at a point distant from the project site but within the specific system or area involved. (Ashe 1982)

On-site - occurring on, adjacent to or in the immediate proximity of the development site. (Ashe 1982)

Out-of-kind replacement - providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically or biologically different from those lost. (FWS Mitigation Policy)

Replacement - the substitution or offsetting of resource losses with resources considered to be of equivalent biological value. However, resources used for replacement represent loss or modification of another type of habitat value. It should be clearly understood that replacement actions never restore the lost fish and wildlife resource--that is lost forever. (From FWS Mitigation Policy)

Restoration - the rehabilitation and return of part of an ecosystem, formerly altered or removed from production, back to effective productivity. (adapted from Barnhart and Boyd 1984)