Chapter 6. Abalone Recovery

Chapter 5 defines recovery in the ARMP as rebuilding abalone populations to a self-sustaining level (reproducing successfully to survive natural changes in abundance), and eventually to a condition where a fishery might be considered. Recovery, by this definition, applies to southern California populations, as well as red abalones in central California outside the Central California Sea Otter Range. Recovery of abalone populations will take considerable effort over a long period of time. At least one abalone, the white abalone, is most likely beyond its reproductive capacity to recover on its own, and has been placed on the federal endangered species list.

Of the seven California abalones, five were targeted in the abalone fishery. Two others, pinto and flat, were never a significant part of the fishery, and little is known about them. The recovery portion of this plan will focus primarily on red, pink, green, black, and white abalones. Nevertheless, flat and pinto abalones will be monitored and included in the activities targeting the primary species.

6.1 Goals

The recovery plan addresses three goals (two interim and one long-term):

1. To reverse the decline of abalone populations that are in jeopardy of extinction
2. To establish self-sustaining populations throughout historic ranges
3. To reach sustainable fishery levels in at least three-quarters of former ranges (Section 7.1.2.1 Criteria for Evaluating Stocks)

Recovery activities are limited when populations are at very low levels. Any activity is likely to depend upon the successful completion of previous work, thus recovery activities are consecutive and stepwise. Abalone species with decreased populations and reduced ranges must first be brought to a self-sustaining level, then allowed to rebuild to a population level where a fishery may be considered. Figure 6-1 outlines the concept of this stepwise recovery approach. Periodic assessment of abalone populations will determine the fulfillment of criteria for recovery. Once a particular criterion has been fulfilled, assessments can progress to measuring the fulfillment of the next criterion.

6.2 Criteria for Evaluation of Resource Recovery

Because recovery is a step-wise process, a set of criteria was developed to assess and evaluate the recovery process as it moves from one step to the next. Two types of criteria are used: size-based and density-based. Criterion 1, a size-based criterion, measures size distribution over the former abalone range. Criteria 2 and 3, both density-based criteria, gauge whether densities have reached MVP levels and fishery levels, respectively.

6.2.1 Size Distribution-based Assessment (Timed Surveys)

Abalone size distribution is used to evaluate whether Criterion 1 has been met. Size frequency can provide information about a local population's reproduction and growth. When possible, large amounts of data are collected from appropriate abalone habitat during Department surveys. In addition to Department assessment surveys,

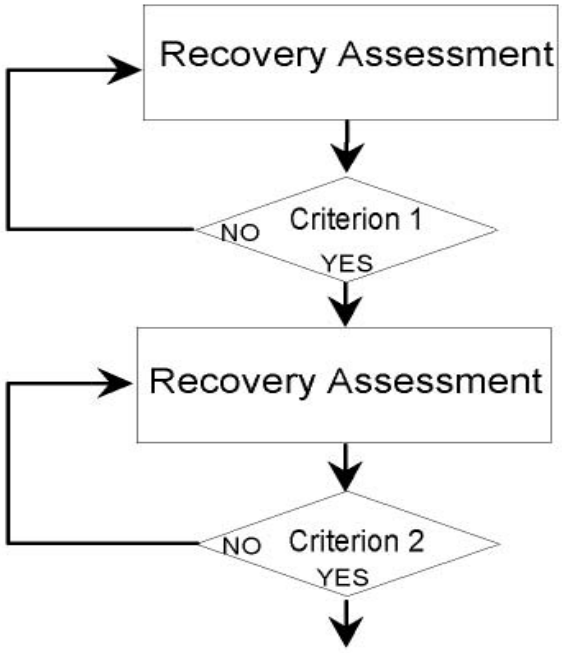

Figure 6-1. Conceptual framework for the recovery approach

size frequency data from a variety of sources can be utilized, such as data gathered at kelp forest monitoring sites within the Channel Islands National Park (CINP). While specific density data for abalone would be useful, conducting detailed, time-consuming, transect-based surveys for rare species is impractical given the lack of available human resources.

Surveying for a defined length of time adds a rough means of comparing many similar surveys. Timed searches are more efficient at finding rare species because they do not require transect set-up and are adaptive, in that searches can be directed at likely habitat without being constrained by transect boundaries. Abalone can be measured in place, providing size frequency data. The location of each dive should be fixed by a Global Positioning System (GPS) unit.

During deep-water remotely operated vehicle (ROV) and submarine searches, a tracking system is commonly employed, thus yielding an estimate of area searched, as well as a count of abalone. Intertidal black abalone searches can be tracked using a GPS unit during surveys. In these instances, density could be obtained as part of a Criterion 1 evaluation.

6.2.1.1 Criterion 1 - Broad Size Distribution Over the Former Abalone Range

Populations are more stable when there are more individuals occupying a broad size range at multiple locations. To evaluate resource conditions using this measure, two categories, intermediate (100 mm to recreational minimum legal size, or RMLS), and large (larger than RMLS), are defined, and each of those categories is further sub-divided into 5 mm groups. When abalone observed during timed surveys (Appendix E Survey Methods) at an index site occupy 90% and 25% of the intermediate and large categories, respectively, then the broad size frequency distribution aspect of Criterion 1 will have been met at that site (Table 6-1 and Section 6.4.1.1 Assessment for Criterion 1). A category smaller than 100 mm is not used, because abalone smaller than 100 mm are usually cryptic and not easily assessed.

Table 6-1. Recovery criteria and Fish and Game block number for recovery areas. Criterion 1 size frequencies are based on past recreational minimum legal size as a break between intermediate and large size ranges. Criteria 2 and 3 are numbers of abalone per hectare.

	Species						
Criteria	Red	Pink	Green	Black	White	Flat	Pinto
Interim							
Size frequency							
Criterion 1:							
Intermediate = 90% Large = 25%	100-178mm >178mm	100-152mm >152mm	100-152mm >152mm	76-127mm >127mm	100-152mm >152mm	76-102mm >102mm	76-102mm >102mm
Emergent Density							
Criterion 2:	2000/ha	2000/ha	2000/ha	2000/ha	2000/ha	2000/ha	2000/ha
Long-term Emergent Density							
Criterion 3:	6600/ha	6600/ha	6600/ha	6600/ha	6600/ha	6600/ha	6600/ha
Recovery areas by Fish and Game block # See also Appendix D	687 689 690 709 710 711 712 709 860 428 455 457 458 464 472	684 685 708 709 719 720 757 761 762 765 829 849 850 860 867 897	684 685 708 719 720 757 761 762 765 829 849 850 860 867	684 689 690 710 711 719 720 757 761 762 765 813 814 829 849 850 860 867	761 762 765 829 849 850 867 871 872 890 897	689 690 860 867	685 687 689 690 708 709 710 711 712 860

Recovery area locations were determined using commercial landing block data and known recreational fishing areas (Appendix D Maps of Historical Commercial and Recreational Abalone Fishing by Fishing Blocks). Key locations, which are smaller areas within a larger recovery area (such as an island) are places where many abalone once occurred. Index sites are selected from key locations, and are where population assessment and recovery activities will be carried out. Index site locations include a mixture of Department-selected locations, and locations where an already established site is monitored by another agency (such as the Channel Islands National Park (CINP) or Catalina Conservancy).

Because the marine environment is dynamic, habitat that once supported abalone may now be incapable of doing so. Alternative index sites may replace those currently selected to take into account changes in the marine environment. Furthermore, sea otter expansion, coastal development, sedimentation, pollution, and disease may act to reduce suitable abalone habitat. If the habitat should become

unsuitable in more than 50% of the recovery areas, then the long-term recovery goal for a fishery cannot be achieved (Section 6.2.2.2 Criterion 3 - Fishery Density Level (6,600 ab/ha)). The interim goal of re-establishing self-sustaining populations becomes the long-term goal.

When size category percentage values (90% intermediate and 25% large) are achieved at one or more index sites, additional timed surveys will be conducted to evaluate the extent of this phase of recovery. If the criterion is only partly met (for instance, if only some of the index sites show evidence of reproduction and growth), timed surveys will continue.

When all the index sites for a species have achieved the size category percentage values, it is likely that the species could then be at or near a self-sustaining level with sufficient reproduction and growth throughout its range, and that there would no longer be any danger of extinction. This situation would fulfill the requirements for Criterion 1, and Criterion 2 would then be addressed.

There remains the possibility, however, that the resource would continue to decline despite enhancement activities (Section 6.4.2 Enhancement Activities). This would be indicated by the continued failure to identify locations with broad size distribution. If this situation occurs, the Department would try to identify the cause(s) of recovery failure, including the role played by withering syndrome (WS). If WS is an influencing factor, the Department may launch an effort to develop WS-resistant broodstock. Formal listing under the federal or state Endangered Species Act (ESA) may be initiated for at-risk species if all enhancement efforts fail.

6.2.2 Density-based Criteria

The density criteria (Criteria 2 and 3) presented here use average density levels derived from red abalone population estimates throughout California, and published research. These density levels are used to identify when recovery has reached MVP and the upper boundary of the recovery range for all species of California abalones (Figure 5-1). As populations recover, future research on individual species may allow refinement of the target densities that more closely reflect individual species population parameters or differences within a species in various regions of the state. Changes to the following target densities based on new data may be adopted by the Commission without full plan amendment pursuant to Section 4.4.1.

6.2.2.1 Criterion 2 - First Density Level (2,000 ab/ha)

When Criterion 1 has been satisfied, emergent density surveys will be conducted in key locations to determine average abalone density.

MVP is the density level that indicates that the population is not at risk for collapse. The MVP used in the ARMP is based on two sources of information: minimum spawning densities determined by Shepherd and Brown (1993), and the density preceding sharp declines of red abalone in southern California (Tegner *et al.* 1989; Karpov *et al.* 1998) (Section 2.1.2.2 Spawning and Fecundity). Shepherd and Brown (1993) found that recruitment started to decline when densities fell below 3,000 ab/ha. Stock collapsed when adult densities fell below 1,000 ab/ha. Comparable densities and consequences were found with red abalone on Santa Rosa Island in southern California. Densities under 1,000 ab/ha were not sustainable and were followed by a collapse of the population (Karpov *et al.* 1998).

An MVP level was therefore established at 2,000 ab/ha for each species based on the best available red abalone density information. The MVP for each species may change as more information on recovering populations is obtained. Satisfaction of Criterion 2 does not trigger consideration of take. Criterion 2 requires that MVP levels be achieved at all key locations in all recovery areas that continue to satisfy Criterion 1 (Section 6.4.1.2 Assessment for Criterion 2).

6.2.2.2 Criterion 3 - Fishery Density Level (6,600 ab/ha)

The attainment of Criterion 3 will directly address the long-term goal of fishery consideration. The targeted emergent abundance to fulfill Criterion 3 is 6,600 ab/ha. This number is based on data from surveys in 1999 and 2000 in the northern California red abalone fishery, which are the best available data for estimating sustainable densities in an ongoing fishery (Section 7.1.2.1 - Criterion 2: Density). Again, this density level may change for each species as more population information is gathered during recovery.

Criterion 3 requires an average emergent density of 6,600 abalone/ha in at least three-quarters of the recovery areas. When the average density of abalone in all index sites within the recovery area reaches 6,600 ab/ha, the area may be considered recovered.

6.3 Fishery Consideration

Once Criterion 3 has been satisfied, an abalone species would no longer be included in recovery and a fishery may be considered. The species would then transition from recovery into management, which is covered in Chapter 7, Abalone Management. Specific details on the fishery consideration parameters are described in Section 7.1.4.1, Planning Process for Fishery Reopening.

6.3.1 Limited Abalone Fishery at Selected Areas at a Reduced Density and Prior to Full Recovery in All Areas (*applies to recovery areas within the moratorium area*)

The Commission may consider abalone (*Haliotis* spp.) fisheries in specific locations that have partially recovered prior to achieving full recovery. This consideration will first be made for red abalone at San Miguel Island using a reduced density criterion. It recognizes that viable abalone populations currently exist, and that a broad size range of abalone is present at San Miguel Island. It also recognizes that densities of abalone appear to be above MVP levels at San Miguel Island, and the fact that no-take reserves implemented after the fishery closure will help to ensure continued abalone populations. Other areas, such as the Farallon Islands, may be considered once data are available to show the acceptable density criterion has been met and the fishery at San Miguel Island proves to be practicable.

The Commission may consider fishing prior to achieving Recovery Criterion 3 (three-quarters of the recovery areas achieving a specified density) in individual areas that show a broad size range and an average abalone density above an established MVP level. The initial abalone density to open a fishery will be developed using sound scientific data and following standard fisheries management guidelines. This number will be based, in particular, on the most recent San Miguel Island abalone density surveys. If populations drop below MVP levels, the fishery will be closed and re-evaluated.

Data collection will continue in any fished area to determine whether populations are stable, increasing, or decreasing. An independent contractor may develop an overall management plan and review data collected each year to make recommendations on any changes to the fishery. Guidelines governing the contractor's responsibilities will be developed jointly by the Department and potential fishery participants with approval by the Commission. Management recommendations made by the contractor will be reviewed by the Department prior to potential Commission action. Cooperative effort for data collection will include fishery participants to maximize the amount of information available.

Strict guidelines for a limited fishery must be implemented to ensure that overall recovery continues in both the fished and unfished areas. Several implementation options will be considered in order to ensure a viable and well-managed fishery. Specific regulations will be developed in consultation with potential fishery participants. The following is a summary of some fisheries management measures that would need to be developed (others measures, in addition to these, may also be necessary):

- Fishery Opening Density Level - This level would be set by the Commission at a level above MVP and would be based upon recent density surveys at proposed harvest areas.
- Total Allowable Catch (TAC) - The TAC would be determined based upon estimates of abalone abundance above minimum legal size. The TAC would be a fraction of this amount to maintain both a sustainable population and an economically viable fishery.
- Recreational and Commercial Allocation - The TAC would be allocated between recreational and commercial take based upon pre-determined criteria established by the Commission. Included in this would be discussions on the number of participants allowed into the fishery. Priority for participation in the commercial fishery shall be given to those persons who held a commercial abalone permit during the 1996-1997 permit year [Title 14, sub-section 5522(e)].
- Regulatory Measures - Specific regulations would be developed cooperatively with potential fishery participants in order to ensure a well-managed fishery. Potential regulatory measures include the following, but would be determined as part of the normal regulatory process:

    - Larger than historic size limits - An equal size limit for commercial and recreational take would be set above the historic size limit. This would help ensure an increased abundance of breeding abalone when reproduction occurs.
    - Restricted seasons - A seasonal fishery may provide for ease of enforcement and allow review of biological survey data to provide management recommendations in the off season. It could also allow for undisturbed reproductive periods.
    - Restricted landing locations - This would help prevent illegal activities by limiting the number of areas where abalone could be landed.
    - Tag requirement for all commercial and recreational abalone taken.

        - By individually marking abalone at point of collection potential illegal take would be limited as all legally taken abalone would be tagged.

Tags could also be used as a source of detailed catch data and be linked individually to specific permittees. Additionally, tag fees could help defray management costs.

- Additional taxes and/or permit fees to support management and enforcement.

6.4 Recovery Activities

Recovery includes assessment and enhancement activities used to hasten the recovery process. Assessment will identify the status of current abalone populations in central and southern California, identify appropriate habitats where enhancement activities can take place, and monitor the success of those activities. The entire stepwise recovery approach with assessment and enhancement activities is shown in the flow chart in Figure 6-2. In the figure, the arrows between assessment and enhancement activities show how the two will join together during recovery. The single alternative approach to recovery, listing under the federal and/or state ESA, is also included in the figure, and discussed further in Section 6.8, Alternative Approaches to Recovery.

6.4.1 Periodic Assessment of Abalone and Essential Habitat

Given the current condition of most abalone populations and the animal's slow growth, long life, and sporadic reproductive characteristics, a great amount of time will be required for populations to achieve a broad size range over a wide area. It would be of little use to conduct expensive surveys (such as band transects) annually for documentation purposes; thus, less frequent surveys will be conducted. Recovery assessment for abalone should be completed within a five-year period for all species. Afterwards, the recovery plan should be re-evaluated using alternatives in Table 9-1.

To help maximize recovery assessments, data from other existing survey programs could be incorporated into the assessments. Data from ongoing, long-term monitoring surveys and general ecological (broad scale) surveys such as the CINP Kelp Forest Monitoring Program and the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) program could be used, as well as information reported by constituents such as former commercial abalone fishermen and recreational divers.

To maximize the efficiency of efforts, two types of assessment surveys will be used. The first type of survey (timed surveys) is very general and quick, and is best for assessing small populations at the beginning of recovery (Criterion 1), while the second type (traditional emergent abalone transect surveys; see Appendix E) is more detailed and takes longer, but is more appropriate for larger populations that are growing towards full recovery (Criterion 2 and Criterion 3).

6.4.1.1 Assessment for Criterion 1

Abalone habitat differences may impose the need for different methods of assessment for some species when addressing Criterion 1:

Intertidal surveys for black abalone - This survey method consists of walking through intertidal habitat at extreme low tide periods, and searching rocky habitat including cracks, ledges, and tide pools.

Subtidal scuba surveys for pink, green, red, white, pinto, and flat abalones - This survey method consists of timed survey techniques as defined in Appendix E, Survey Methods. Timed surveys are used for Criterion 1 evaluation when scuba diving is used.

Additionally, scuba surveys for the Channel Islands marine protected areas (MPAs) and CRANE/PISCO monitoring, which are done on an annual basis at selected sites, will be used to gather data for Criterion 1 and all other criteria during recovery.

ROV and submarine surveys for white abalone - The use of remote viewing equipment and submarine searches precludes the easy measurement of individual abalone, but laser reference points can assist in obtaining sizes for emergent abalone. ROV and submarine surveys are GPS-tracked, thus an estimate of the habitat area covered can be obtained. Even though ROV and submarine surveys provide density measures, they may not be as random as subtidal scuba surveys. Criterion 1 assessments should be conducted every five years, and data to satisfy this criterion should be evaluated for each species. The initial recovery assessment under the ARMP is scheduled for completion in 2006.

6.4.1.2 Assessment for Criterion 2

The recovery assessment at this level will consist of density-based surveys to obtain emergent density estimates as well as size frequency information. Density and size frequency will be used to create a baseline database which will be important in any fishery management model that includes a quota.

As in the assessment for Criterion 1, initial recovery assessment will take place at index sites. When abalone populations at the index sites reach Criterion 2 levels, the recovery assessment will expand to encompass all of the key locations (see Tables 6-3 through 6-8). Once all key locations attain Criterion 2 levels, the second interim goal of establishing self-sustaining populations throughout historic abalone ranges will have been fulfilled.

6.4.1.3 Assessment for Criterion 3

Recovery assessment will be conducted at the index sites. When abalone populations there reach the Criterion 3 levels, the long-term goal of reaching sustainable fishery levels in at least three-quarters of the former range will be met.

6.4.2 Enhancement Activities

A variety of activities are available to assist the recovery of depleted stock. The first step towards the recovery of abalone populations in southern California was the closure of all abalone fishing south of San Francisco Bay. While the closure removes the impact of fishing mortality on abalone, assuming no poaching, it is a passive form of population enhancement. Continuation of the closure until a species has recovered is an underlying tenet of the ARMP. Further steps include a range of activities to prevent extinction of threatened species, assist rebuilding, or increase the recovery rate. Enhancement activities may be the only way to fulfill the interim recovery goals. As populations recover and become self-sustaining, the need for these recovery activities should be re-evaluated.

Recovery activities under the ARMP must not conflict with federal law. Both the federal ESA and the MMPA have provisions that may supersede or impact recovery efforts. ESA-listed species such as white abalone and sea otters are under federal, not state, jurisdiction.

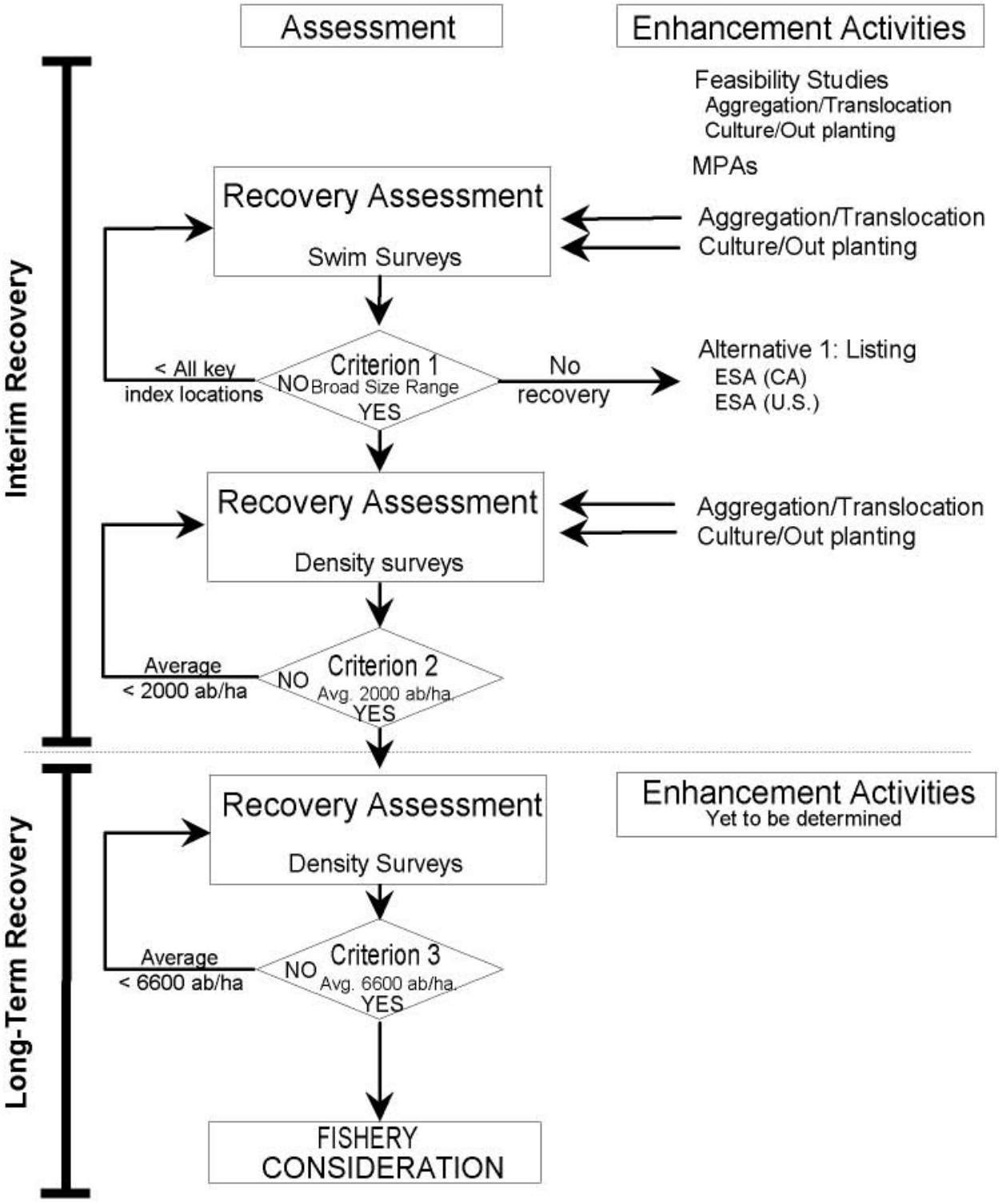

Figure 6-2. Flowchart of the recovery approach

6.4.2.1 Translocation or Aggregation of Adult Animals

Translocation and aggregation of adult abalone are similar recovery techniques. Both involve the placement of abalone in closely aggregated groups in an attempt to bolster successful reproduction, with the end result of increasing local populations. The difference between the two techniques is in the magnitude of distance that abalone are transported to make the groupings. Translocation involves moving individuals away from areas at risk (due to poaching, pollution, etc.), or to distant areas in order to expand the range of the population by re-introduction. Aggregation is the rearranging of abalone within a given area so that they are nearer to each other. This is useful when an area's population is depleted and the remaining animals are spread too far apart for reproduction to occur.

There is evidence that translocation of large abalone could be an effective way to bolster local populations. Tegner (1992) indicated that relocating adult broodstock is one of the few approaches to enhancement that has shown some promise. The study involved green abalone, but may be applicable to other species. In time, these small, aggregated groups could enlarge due to increased reproductive success.

Drawbacks to translocation and aggregation techniques include mortality during collection, transportation and replanting, absence and depletion of the source population, increased vulnerability to poaching, and disease transmission. Tegner (1992) reported a 10% mortality rate associated with transportation and replanting activities. Consideration of these drawbacks will be necessary when selecting sites for translocation and aggregation activities.

6.4.2.2 Larval Out-planting

Larval out-planting releases millions of cultured larvae into optimal habitat areas. Although there is very high mortality of released larvae at the early stages of growth, saturating the habitat with larvae on consecutive occasions may have a positive effect on recovery. An additional benefit is the reduced cost of culture by releasing the abalone early in their development. This type of enhancement has been attempted and shows some promise. Further feasibility studies are necessary to determine if this technique is useful on a large scale. The Department is currently planning larval out-planting feasibility studies using red abalone at the northern Channel Islands. If the technique proves successful, it could be applied to other abalone species. Former commercial abalone fishermen are supportive of this technique and may volunteer time and resources to conduct out-planting.

6.4.2.3 Captive Breeding to Obtain Large Individuals for Out-planting

Tegner (1992) found that translocating large abalone was an effective means of increasing local numbers. However, a disadvantage to this method is the lack of available and sufficient source populations in the wild. Aquaculture offers the ability to grow abalones to large size. Of the California abalones, red and green (Lapota *et al.* 2000) are currently being grown to sizes exceeding 100 mm. Cultured white abalone are currently in the early stages of being grown to large size as a potential source of individuals to increase local populations. Similar work for black abalone has been proposed, particularly for developing a WS-resistant strain.

While out-planting larger individuals offers the advantages of decreased natural predation and an increase in local reproductive potential, these animals are

more likely to be poached (Henderson *et al.* 1988). Thus, it is important to have locations where out-planted abalones can be protected. Cultured abalone may behave differently from naturally-occurring abalone, and may not survive as well as native stock under natural conditions.

The cost of raising abalones to large size is high, but may be the most cost-effective method for rebuilding populations that are at risk of extinction.

6.4.2.4 Establishing Marine Protected Areas

Edwards (1913) was the first to recognize that local declines in abalone could ultimately lead to loss of the resource as a whole. He was visionary in suggesting the establishment of protected reservations to function as breeding centers for abalone at 5 to 10 mile intervals along the coast. MPAs for abalone could only be used in areas that still support minimum viable populations. MPAs, particularly marine reserves where no commercial or recreational take is allowed, are designed to conserve ecosystems and habitat, and reduce threats to fishery sustainability. MPAs would benefit abalone recovery by providing a natural habitat where individuals could form the aggregations necessary for reproduction.

Abalone-related MPAs should be located in remote areas away from population centers in order to reduce take, and the effects of pollution. Remote areas should be selected that would also protect abalone as long as possible from the arrival of potential natural predators, such as sea otters. It is likely that areas meeting this requirement could be found at the southern Channel Islands (San Clemente and Santa Catalina Islands). An MPA at Santa Barbara Island was established in 2003 that may meet this requirement.

A second requirement is effective enforcement. Currently, there are few areas along the southern California mainland where abalone could be enhanced because protection of the abalone cannot be reasonably ensured. However, certain areas have onsite enforcement presence as well as frequent Department enforcement patrols and may meet this requirement.

Once abalone populations reach a self-sustaining level, recovery can move into the long-term phase. MPAs would continue to benefit abalone during the long-term phase by providing protection while the population grows towards fishery sustainability. After recovery, MPAs would continue to provide areas where a complete size range of abalone could thrive in a natural marine environment. These areas would provide a continuous source of reproductive potential in larger older abalone.

Specific areas for MPAs were not originally proposed in this plan because the proposal of MPA sites will take place under the MLPA. A list of criteria for MPA requirements for abalone under the ARMP are listed in Section 7.1.1.3, Marine Protected Areas. A network of MPAs at the Channel Islands National Marine Sanctuary were approved by the Fish and Game Commission and went into effect on April 9, 2003 (Figure 6-3). Of the established MPA sites, ten would provide areas suitable for abalone recovery.

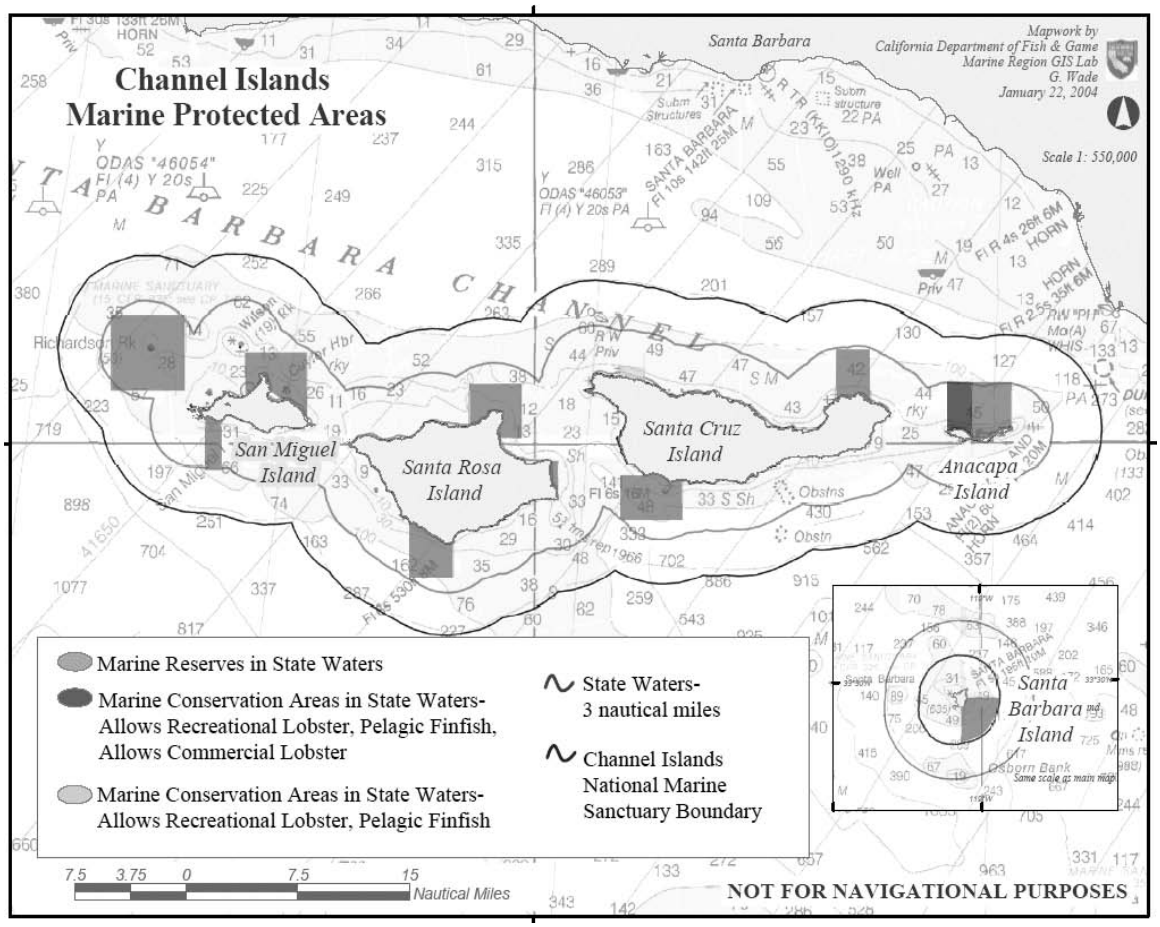

Figure 6-3. Marine Protected Areas in the Channel Islands National Marine Sanctuary

6.4.3 Genetics and Disease Research

Active enhancement of abalone stock will include aggregation, translocation and introduction of aquacultured abalone larvae, seed, or large individuals. Before any of these activities are attempted, certain genetic and disease concerns should be specifically addressed.

6.4.3.1 Genetics Research

In populations with extremely low abundance levels, there is a strong possibility that individuals may be genetically similar. Using these individuals in enhancement programs may result in restricted genetic characteristics (genetic bottlenecks) and cause reduced genetic diversity. A survey of individuals from many locations throughout the species' range should be conducted in order to estimate genetic diversity.

Knowledge of abalone genetics may be applied to genetic tag methods used to evaluate the success rates of out-planting. Genetic markers that may be unique to the Southern California Region could be a useful tool in enforcement of the moratorium.

Enhancement activities such as translocation and out-planting have potential genetic consequences from mixing genotypes of remote populations and introducing cultured strains to natural populations. A part of active enhancement efforts should

include attention to genetic concerns. Samples of individual abalone can be taken non-destructively and stored for future analysis.

Aggregation of abalones is the only activity that would not require genetic evaluation before proceeding, but genetic sampling would still be conducted as part of the overall abalone genetic investigation.

6.4.3.2 Disease Research

Disease, particularly WS, constitutes an important factor which might limit recovery operations in southern California for some species. Aggregating, out-planting and translocating individuals in California must allow for the possible effects of WS. Further research is needed on the effects of WS on each species, and on possible resistance to WS. If resistance is not assured, such recovery operations should not be pursued.

6.5 Challenges to Abalone Recovery

There are a variety of challenges that may hinder abalone recovery. The extent of recovery for each species will depend on the severity of these challenges, which are identified and described below.

6.5.1 Disease

For invertebrates, resistance to disease develops at the level of the population rather than being acquired by individuals through previous exposure. The potential for development of genetically-based resistance at the population level is enhanced by large population size. If a fishery were opened or continued during an acute disease event, the healthy, and possibly most resistant, individuals would be removed by the fishery.

The extent to which WS has played a role in the apparent failure of abalone population recovery since fishery closures is unknown. WS has a strong temperature component, in that elevated sea water temperature stimulates the development of the disease, which can be lethal (Friedman *et al.* 1997, Moore *et al.* 1997). Therefore, the impact of WS will be most apparent following severe El Niños and may increase if global climate change results in increased seawater temperatures. Recovery options must take into consideration the possible effects of this disease.

The Department monitors aquaculture facilities for introduced organisms and disease. There is currently a restriction on out-planting abalone from facilities which have not met certification standards. These standards must be followed in all appropriate enhancement operations.

6.5.2 Sea Otters

Sea otters constitute a potential threat to the recovery of an abalone fishery in the Southern California Region. While sea otters and abalones co-existed along the California coast before 1850, the abalone likely occupied cryptic habitat inaccessible to otters, in crevices and under boulders. The establishment of an abundance of large invertebrates, such as abalone, crabs, sea urchins, and clams, along the Pacific Coast is likely the result of severe declines in sea otters in the 19th century due to fur trade hunting. The loss of the central California red abalone fishery to sea otters in the 1960s

demonstrated the effect that sea otters have on a fishery (Wendell 1994). Similar impacts on abalone fisheries occurred in British Columbia, Canada (Watson and Smith 1996; Watson 2000).

Although the central California fishery for red abalone was eliminated by sea otters, red abalone still exist in cryptic habitat under rocks and in crevices inaccessible to otters, and will likely be self-sustainable at lower population numbers and biomass (Hines and Pearse 1982). The current abalone population in central California is probably at the same level it was prior to human exploitation of sea otters. Although this cryptic population exists within the Central California Sea Otter Range, there are insufficient individuals available to conduct a fishery. If a fishery were allowed, habitat damage may result from moving rocks to search for abalone in cryptic habitat, and additional opportunities would be created for selling illegal take. A fishery based on smaller (cryptic) sizes would put the crevice-dwelling refuge population at risk.

In southern California there is concern that re-colonization by the sea otter would reduce an already depleted resource to even lower levels, possibly to extinction. Southern California populations need focused assessment to identify whether the crevice dwelling individuals are present in sufficient numbers to sustain the resource, if sea otters become a factor.

6.5.3 Other Challenges to Abalone Recovery

For a description of other challenges to abalone recovery, see Section 6.4.2.4, Establishing Marine Protected Areas; Chapter 8, Abalone Enforcement Activities, and Section 2.1.9, Mortality.

6.6 Recovery Approach

Within the overall strategy for abalone recovery, the unique needs of each abalone species must be considered. To facilitate an organized approach, the recovery needs outlined below are sequentially numbered and divided into specific tasks within four recovery categories. Addressing these needs for each species will require the coordination of tasks. Where possible, the needs of multiple species will be addressed simultaneously. All of the recovery plans have similar task elements; however, there are differences in implementation (Table 6-2).

6.6.1 The General Recovery Plan

The recovery tasks are sequentially numbered for ease of identifying specific tasks. Task numbers do not indicate that they must be undertaken in sequential order. Implementation of tasks for each species is outlined Chapter 9, Implementation (Activities, Timelines and Cost) in Table 9-1.

6.6.1.1 Assessment of Habitat and Stock

<u>Exploratory Surveys – Task 1</u>

A primary need at the beginning of the recovery process is to assess the current status of all five species throughout the entire range. Exploratory surveys will be conducted at all key locations. Some of this work has already begun for some species (red, pink, black, and white abalones) but for no species is the assessment complete. Knowing the baseline status of the population is important to define the level of risk

Table 6-2. List of recovery activities with an estimate of field time required to complete the activity

Activity and task	Species	Time	Field time required
Assessment of Habitat and Stock			
Exploratory Surveys (Task 1)	R	I	5 dive days
	P	I	17 dive days (10 primary, 7 secondary*)
	G	I	24 dive days (14 primary, 10 secondary*)
	B	I	30 days low tide sampling
	W	I	40 days split between submersible & ROV
Detail Surveys (Task 2)	P	I	7 dive days
	G	I	15 dive days
	W	I	undetermined
Assessing Recovery (Task 3)	R	L	10 dive days over 5 yr period
	P	L	23 dive days over 5 yr period
	G	L	24 dive days over 5 yr period
	B	L	30 days low tide sampling over 5 yr period
	W	L	40 days submersible / ROV over 5 yr period
Research (enhancement activities)			
Culture (contract or support) (Task 4)	R	I	1 dive day to collect broodstock, 6- 12 mo to receive larvae
	G	L	continuous after feasibility study
	B	L	8 days broodstock collection, est. 7-10 yr culture
	W	I,L	continuous until de-listed
Out-planting Feasibility Studies (Task 5)	R(larval)	I	15 dive days (setup), 10 dive days/yr for 5 yr
	G	I	24 dive days/yr for 4 yr
	B	I	15 days/yr low tide sampling
	W	I, L	10 dive days/yr , 10 days/yr ROV for 5 yr
Aggregation Feasibility Study (Task 6)	P	I	7 dive days (setup), 5 dive days/yr for 4 yr
	G	I	7 dive days (setup), 5 dive days/yr for 4 yr
Translocation Feasibility Study (Task 6)	R	I	10 dive days (setup), 10 dive days/yr for 4 yr
	B	I	20 low tide sampling days/yr. for 4 yr
Aggregation (Task 7)	All	L	undetermined
Translocation (Task 7)	All	L	undetermined
Out-planting (adult, larval) (Task 8)	All	L	undetermined
Research (genetics and disease)			
Estimate Genetic Diversity (Task 9)	All	I	2 yrs. per species to complete lab analysis
Study of Resistance to W S (Task 10)	B	I	Estimated 2 yr
Involvement in Federal White Abalone Recovery Team (Task 11)	W	I, L	continuous until de-listed

Note: R= red, P= pink, G= green, B= black, W= white, I=interim, L=long-term
*see Sections 6.5.2.2 and 6.5.2.3

for survival of the species as well as to determine the level of recovery needed. This information will help prioritize recovery efforts so that species that are at risk of local extinction will receive more effort than those that are not. Exploratory surveys will provide information on current population levels and the location of aggregations. This information will be used to identify areas to conduct recovery activities, and areas to protect.

The exploratory surveys for most species will be accomplished using timed surveys (Tables 6-3 through 6-8). Surveys of deep, remote, offshore locations for white abalone will be conducted using a GPS-tracked submarine and/or ROV. The exploratory survey for black abalone will use an intertidal timed search survey conducted during low tide periods. Survey methodologies are explained in Appendix E, Survey Methods.

These surveys will produce a GPS record of the general distribution of remaining abalone populations and a general habitat description. The generalized stock assessment will also provide the current status of the population at key locations. This information is important for determining the baseline from which recovery will be measured. Decisions on where and what type of recovery activities to employ can be made based on this information.

A collateral benefit of this task is that data obtained from these exploratory surveys would include information on multiple abalone species distributions and habitat, since the depth ranges of these species overlap. Information on other invertebrates, fishes, and plants may be useful in the assessment and management of those species.

Detailed Surveys of Known Abalone Habitat – Task 2

The detailed surveys will expand upon the initial knowledge gained from exploratory surveys by providing precise habitat descriptions, a baseline density estimate, and locations of abalone aggregations. Detailed surveys could be undertaken immediately following the exploratory surveys (Task 1) at particular locations on the same trip.

The detailed surveys will be similar to timed swim surveys, except that a diver tracking device will be employed to map the divers' movements and record habitat and abalone location information (Appendix E Survey Methods).

This task will produce a detailed map of abalone habitat at selected areas. The habitat information will be placed into a geographic information system (GIS) and used to generate habitat and community maps. Suitable areas for potential recovery activities could be identified at index sites or key locations. Identifying specific habitat types is essential for optimizing recovery efforts. The habitat information in the GIS would also be useful for other projects and species assessments.

Assessing Recovery – Task 3

Periodic assessment of any changes in the population is the core research task that will directly evaluate whether recovery criteria and goals have been satisfied. The survey technique used will vary depending on the level of recovery.

Assessment surveys for Criterion 1 will be the timed survey, intertidal walks, and submersible/ROV surveys (Appendix E Survey Methods). Following the achievement of Criterion 1, emergent density transects will be used to assess the achievement of Criterion 2 and Criterion 3. Other types of survey data will be incorporated from existing long-term sites monitored by other organizations and agencies.

This task is crucial for determining the achievement of each recovery criterion. If this task is not completed, there will be no way to determine if a species is recovering or heading towards extinction.

Recovery assessments may sometimes encompass multiple abalone species, because some abalone species occur in the same key recovery locations and have overlapping depth ranges.

6.6.1.2 Research: Enhancement Activities

Develop or Support Existing Culture Programs – Task 4

Since the Department has no facilities for raising abalone, it must encourage abalone aquaculture companies to undertake this work. The Department will provide assistance with broodstock collection, and The Department's Shellfish Health Laboratory will certify facilities, assist with disease issues, and certify individual lots for outplanting (see Tasks 5 and 8).

The Department has already encouraged culture programs for white and green abalones for recovery out-planting. Culture programs for black and red abalones are planned and will be developed in the near future. The current culture programs and the planned black abalone program will raise abalone to adult sizes for out-planting into the natural environment. The planned red abalone culture program will produce larvae for out-planting. The production of adult and larval seed will initially be for small scale out-planting feasibility studies. If the feasibility studies show that the technique is worthwhile, the culture programs will expand operations to produce larger quantities of seed for out-planting. Inherent in the culture of abalone is the collection of wild broodstock. If out-planting activities progress to a larger scale to enhance recovery (Task 8), then formal controls to limit the collection of broodstock from the wild will be instated. Controls on broodstock collection will ensure that broodstock collection areas are not negatively impacted to the extent that recovery is significantly hampered.

In the course of culturing broodstock offspring, it may be necessary to cull a certain percentage of the population to prevent overcrowding and to maintain optimal growth rates. These culled individuals could be used for further research in pathology, larval or juvenile ecology, and other areas that would help increase the success of out-planting.

Feasibility Study for Out-planting – Task 5

The out-planting of adult or larval abalone involves new techniques which must be evaluated before applying them on a larger scale. The Department must also develop protocols and determine locations for out-planting. Finding protected areas or deep areas that might provide *de facto* protection for the out-planted abalone is also important. Results should be evaluated at regular intervals, and if positive results cannot be verified after five years, this technique should be reconsidered. If failure is due in part to WS infection after out-planting, development and out-planting of WS-resistant strains, if possible, will be considered (Section 6.6.1.3 Research: Genetics and Disease Studies, Task 10).

The main product from this task will be a scientifically-based determination of the effectiveness of larval and adult out-planting enhancement techniques. An additional product will be the establishment of localized groups of abalone which may help to increase reproductive success. This task will also provide an out-plant protocol (for both adults and larvae) that could be applied to other abalone recovery efforts.

Feasibility Studies for Aggregation/Translocation – Task 6

In localized areas within index sites, remaining abalone populations may be too dispersed for effective reproduction to occur. "Local areas" are defined as locations where surveys would normally be conducted. Aggregation of remnant abalone may be useful as a means of facilitating reproduction. Aggregation would not require genetic or

disease evaluation of individuals, because individuals would be taken from natural local populations. Aggregation would only be appropriate for intertidal and subtidal SCUBA diving sites. Aggregation feasibility studies will be conducted using pink and green abalones.

The steps for aggregation involve the following:

- Survey area for abalone
- Mark location of abalone
- Evaluate numbers to determine if aggregation is warranted
- Locate appropriate habitat in which to aggregate
- Move abalone
- Tag abalone, if possible
- Determine GPS location
- Post-survey evaluation

A primary concern is keeping abalone that are part of the local unit (in other words, part of a rocky point, cove, or kelp bed) in that area. The number and density of abalone which would trigger an aggregation study needs to be determined.

Translocation involves moving abalones longer distances, such as between islands. Translocation of abalone would be used to re-introduce animals to areas once populated by a high abundance of abalone. Translocation feasibility studies will be completed using red and black abalones. Evaluation of donor and receiving locations should be made before an operation is conducted. Genetic and disease considerations will be addressed prior to any translocation.

The steps for translocation involve the following:

- Determine and evaluate new location, including the presence of abalone, good habitat, food, and protection
- Determine source location, including the presence of sufficient animals
- Move abalone
- Tag abalone, if possible
- Determine GPS location
- Post-survey evaluation

The results of aggregation and translocation should be evaluated at regular intervals. If positive results from the use of these techniques cannot be verified after five years, then the methods of enhancement should be reconsidered.

Aggregation and translocation are probably the only recovery activities that can be done for red, pink, green, and black abalones at the Channel Islands within the next five to seven years. Information obtained might also be applicable to the recovery of other abalone species.

Aggregation or Translocation – Task 7

If the feasibility studies prove that aggregation and translocation are successful recovery activities, the next step is to evaluate following CEQA guidelines and, if appropriate, apply them to a larger recovery area. Based on the exploratory survey information, locations will be identified for either the aggregation or translocation recovery activity. Specific methodology will be determined by the results of the

feasibility studies. The immediate product will be an increase in the number of abalone in an aggregation, followed by successful reproduction and recruitment in areas where this task is applied. If shown to be effective on a large scale, aggregation and translocation are probably the best and most cost-effective recovery activities to use for all abalone.

Out-planting – Task 8

If feasibility studies prove that larval and adult out-planting are successful recovery activities, the next step is to evaluate these activities following CEQA guidelines and, if appropriate, apply them to a larger recovery area. Based on previous survey information, locations will be identified for out-planting. Methodologies determined during the feasibility study will be used to carry out this task on a larger scale in the selected locations. The immediate product will be an increase in the number of abalone in the areas where out-planting occurs.

6.6.1.3 Research: Genetics and Disease Studies

Genetic Study: Estimation of Genetic Diversity – Task 9

A survey to collect genetic material from individuals at many locations within the species range should be conducted to estimate genetic diversity. Such surveys can be conducted without harm to the abalone. Very small tissue samples can be taken from abalone found on the exploratory surveys in Task 1. The equipment needed to conduct genetic testing is available from academic institutions (such as the University of California). Population specialists under contract would evaluate genetic data.

Evaluation of Resistance to WS – Task 10

Although rare and widely dispersed, survivors of some Channel Islands and mainland black abalone populations remained long after most of the population was removed by WS. These individuals may harbor genetic resistance to WS, which will be essential for the development of a black abalone culture and out-planting program.

The Department's Shellfish Health Laboratory will collect a limited number of these animals and compare their ability to resist WS relative to black abalone from north-central California that have not experienced mass mortality. Black abalone that survive the laboratory challenge will be treated with antibiotics to eliminate the WS pathogen, and then conditioned for spawning to produce WS-resistant progeny. This method could also be applied to other species if WS is found to be a critical factor for their recovery.

6.6.2 Recovery Plan Elements for Individual Species

6.6.2.1 Red Abalone

Task 1 - Exploratory Surveys

The majority of the southern California population is currently concentrated at San Miguel Island, which is the western-most of the northern Channel Islands (Figure 63). Exploratory surveys will focus on Santa Rosa and Santa Cruz Islands, where red abalone historically occurred. Surveys will take place within the blocks and key locations listed in Table 6-3.

Task 2 - Detailed Surveys of Known Abalone Habitat

This task is not required for red abalone. Sufficient information is already available.

Task 3 - Assessing Recovery

Assessment surveys will be conducted at index sites and key locations in southern and central California (Table 6-3).

Task 4 - Develop or Support Existing Culture Programs

A certified (sabellid-free) aquaculture facility in southern California will be selected for culturing red abalone larvae for out-planting feasibility studies.

Task 5 - Out-planting Feasibility Study

Red abalone is the best candidate for a feasibility study on larval out-planting because red abalone larvae are readily available from established aquaculture facilities. The out-planting study will be located at Santa Rosa and Santa Cruz Islands.

Task 6 - Aggregation/Translocation Feasibility Studies

Translocation feasibility studies will be conducted at Santa Rosa Island and/or Santa Cruz Island. The source for translocation abalone will be San Miguel Island.

Task 7 - Aggregation or Translocation

These recovery techniques will be employed in the appropriate key locations.

Task 8 - Out-planting

Out-planting will occur in the appropriate key locations.

Task 9 - Genetics

A genetics study will be completed to determine if sub-populations exist.

Table 6-3. Key locations for recovery of **red abalone** in southern and central California

Area	Block no.	Index	Key location
San Miguel Island	690 & 689	X	Crook Point to Cardwell Point
	689 & 690	✓	Bay Point to Harris Point
	690		Harris Point to Otter Harbor
	690	X	Castle Rock (Otter Harbor to Point Bennett)
	690		Point Bennett to Judith Rock
	690	✓	Judith Rock to Crook Point
Santa Rosa Island	689		Talcott Shoal (Tecolote Point to Sandy Point)
	712		Sandy Point to Cluster Point
	711	X	Cluster Point to South Point
	711	✓	South Point to Ford Point
Santa Cruz Island	687	X	West Point to Black Point
	687 & 709		Kinton Point to Posa Anchorage
	709	✓	Gull Island (Laguna Harbor to Morse Point)
San Diego Area	860		La Jolla (Point La Jolla to Bird Rock)
	860		Point Loma (Mission Bay to Rathay Point)
	860	✓	Point Loma (Rathay Point to Ballast Point)
Central California	457	X	SW Farallon Islands
	464	X	Fitzgerald Marine Reserve (San Mateo Co.)

X - Proposed CDFG index recovery site ✓ - External agency monitoring site

6.6.2.2 Pink Abalone

Task 1 - Exploratory Surveys

Areas selected for exploratory surveys in southern California are divided into primary and secondary tiers. The primary areas will encompass the CDFG blocks where most landings occurred for both the recreational and commercial fisheries. The secondary areas will be surveyed at a later date when time, weather, and personnel availability allow. Primary surveys will be conducted at Santa Cruz Island, Anacapa Island, Santa Barbara Island, and Santa Catalina Island; and the mainland at San Diego. Secondary survey areas include San Clemente Island, Cortes Bank, Palos Verdes Peninsula, and Dana Point. The specific areas where surveys will occur are listed as key locations for recovery in Table 6-4.

Task 2 - Detailed Surveys of Known Abalone Habitat

Areas for detailed surveys will be selected based on findings of exploratory surveys at the primary islands. Areas at San Clemente Island will be selected based on past surveys.

Task 3 - Assessing Recovery

Assessment surveys will be conducted at index sites and key locations (Table 6-4).

Task 4 - Develop or Support Existing Culture Programs

There is no existing or planned culture program for pink abalone.

Task 5 - Out-planting Feasibility Study

Because there is no culture program, out-planting cannot be undertaken at this time.

Task 6 - Aggregation/Translocation Feasibility Studies

An aggregation feasibility study will be conducted on the west and south sides of San Clemente Island.

Task 7 - Aggregation or Translocation

These recovery techniques will be employed at the appropriate key locations according to the results of Tasks 1 and 2.

Task 8 - Out-planting

This recovery technique will be employed if a culture program is developed which will supply larvae and/or seed abalone.

Task 9 - Genetics

A genetics study will be completed to determine if sub-populations exist.

Table 6-4. Key locations for recovery of **pink abalone** in southern California

Area	Block no.	Index	Key location
Anacapa Island	684	✓	Bat Ray Cove to West End
	684	✓	West End to East Fish Camp
	684	✓	East Anacapa
Santa Cruz Island	685	✓	Cavern Point to San Pedro Point
	685		San Pedro Point to Sandstone Point
	708	✓	Sandstone Point to Blue Banks
	709		Blue Banks to Laguna Harbor
	709 & 710	✓	Gull Island (Laguna Harbor to Morse Point)
Santa Barbara Island	765	✓	South Side (Sutil Island to Grave Canyon)
	765	X	West Side (Webster Point to Sutil Island)
	765	✓	North Side (Arch Point to Webster Point)
Santa Catalina Island	761		Isthmus Cove Area (Ship Rock, Bird Rock etc.)
	761	✓	Long Point to Blue Cavern Point
	761	✓	Little Harbor to Ben Weston Point
	761		Ben Weston Point to Painted Cliffs
	762	X	Eagle Reef to Stony Point
	762		Stony Point to West End
	762		West End to Ribbon Rock
	762	X	Ribbon Rock to Catalina Head
	762		Avalon to Long Point
San Clemente Island	829		Northwest Harbor to West Cove
	849		Little Flower to White Rock
	849 & 850	X	West Cove south 3 nautical miles
	850		Eel Point north 3 nautical miles
	850	X	Eel Point to Mail Point
	850		Mail Point to Lost Point
	849 & 867		Lost Point to Cove Point
	867	X	China Point to Pyramid Head
Cortez Bank	897		Bishop Rock
Palos Verdes Peninsula	720		Haggerty's to Lunada Bay
	720		Lunada Bay to Abalone Cove
	719		Abalone Cove to Point Fermin
Dana Point	757		Pelican Point to Laguna Main Beach Laguna Main
	757		Beach to Dana Point
San Diego Area	860		La Jolla (Point La Jolla to Bird Rock)
	860		Point Loma (Mission Bay to Rathay Point)
	860	✓	Point Loma (Rathay Point to Ballast Point)

X - Proposed CDFG index recovery site ✓ - External agency monitoring site

6.6.2.3 Green Abalone

Task 1 - Exploratory Surveys

Few areas have been thoroughly evaluated for remaining green abalone populations; however, evidence suggests that populations are at very low levels. The primary survey areas will be centered around the southern Channel Islands: San Clemente Island, Santa Catalina Island, and Santa Barbara Island. Secondary survey areas include Santa Cruz Island, Anacapa Island, Palos Verdes Peninsula, Dana Point, and the San Diego area (Table 6-5).

Task 2 - Detailed Surveys of Known Abalone Habitat

Areas for detailed surveys will be selected based on findings of exploratory surveys at the primary survey islands. Areas at San Clemente Island will be selected based on past surveys.

Task 3 - Assessing Recovery

Assessment surveys will be conducted at index sites and key locations (Table 6-5).

Task 4 - Develop or Support Existing Culture Programs

The culture of green abalone is being conducted by the U.S. Navy and the City of San Diego. The project received grant funding from the California Resources Agency in 2002.

Task 5 - Out-planting Feasibility Study

The Navy project is focused on out-planting large (3 to 4 in.) green abalone in the vicinity of Point Loma.

Task 6 - Aggregation/Translocation Feasibility Studies

An aggregation feasibility study will be conducted at either San Clemente or Santa Catalina Island.

Task 7 - Aggregation or Translocation

These recovery techniques will be employed at the appropriate key locations (Table 6-5).

Task 8 - Out-planting

This recovery technique will be employed at the appropriate key locations (Table 6-5).

Task 9 - Genetics

A genetics study will be completed to determine if sub-populations exist.

Table 6-5. Key locations for recovery of **green abalone** in southern California

Area	Block no.	Index	Key location
Anacapa Island	684	✓	Bat Ray Cove to West End
	684	✓	West End to East Fish Camp
	684	✓	East Anacapa
Santa Cruz Island	685	✓	Cavern Point to San Pedro Point
	685		San Pedro Point to Sandstone Point
	708		Sandstone Point to Blue Banks
Santa Barbara Island	765	✓	South Side (Sutil Island to Grave Canyon)
	765	✓	West Side (Webster Point to Sutil Island)
	765	X	North Side (Arch Point to Webster Point)
Santa Catalina Island	761	X	Isthmus Cove Area (Ship Rock, Bird Rock)
	761	✓	Long Point to Blue Cavern
	761	✓	Point Little Harbor to Ben Weston Point
	761		Ben Weston Point to Painted Cliffs
	762	✓	Eagle Reef to Stony Point
	762	X	Stony Point to West End
	762		West End to Ribbon Rock
	762	X	Ribbon Rock to Catalina Head
	760 & 761		Avalon to Long Point
San Clemente Island	829		Northwest Harbor to West Cove
	849		Little Flower to White Rock
	849 & 850	X	West Cove south 3 nautical miles
	850		Eel Point north 3 nautical miles
	850	X	Eel Point to Mail Point
	850		Mail Point to Lost Point
	849 & 867		Lost Point to Cove Point
	867	X	China Point to Pyramid Head
Palos Verdes Peninsula	720		Haggerty's to Lunada Bay
	720		Lunada Bay to Abalone Cove
	719		Abalone Cove to Point Fermin
Dana Point	757		Pelican Point to Laguna Main Beach
	757		Laguna Main Beach to Dana Point
San Diego Area	860		La Jolla (Point La Jolla to Bird Rock)
	860		Point Loma (Mission Bay to Rathay Point)
	860	✓	Point Loma (Rathay Point to Ballast Point)

X - Proposed CDFG index recovery site ✓ - External agency monitoring site

6.6.2.4 Black Abalone

Task 1 - Exploratory Surveys

Black abalone distribution is relatively well known throughout southern California, including the Channel Islands. This species also occurs in central California, where information about its distribution and abundance is limited. However, surveys in the Monterey/Carmel area in the northern part of central California suggest that a fairly good population remains. Exploratory surveys will be conducted in central California (from San Luis Obispo County to Mendocino County) to determine relative abundances of black abalone, and whether these populations could serve as sources of animals for translocation to depleted areas in southern California.

Task 2 - Detailed Surveys of Known Abalone Habitat

This task is not needed for black abalone because sufficient information is already available.

Task 3 - Assessing Recovery

Surveys will be conducted at index sites and key locations (Table 6-6).

Task 4 - Develop or Support Existing Culture Programs

Currently, black abalone has not been successfully cultured. Developing a culture program for black abalone is important to provide stock for out-planting, and in order to answer questions regarding the effects of, and resistance to, WS.

Task 5 - Out-planting Feasibility Study

Locations for out-planting must be well protected from poaching. Black abalone are accessible and easily seen during low tide periods and thus are very susceptible to poaching. Few (if any) areas on the southern California mainland would be acceptable for enhancement. Areas at the Channel Islands or mainland areas along the central California coast would provide suitable habitat that could be adequately protected.

Task 6 - Aggregation/Translocation Feasibility Studies

Abalone from the northern portion of the central California coast may be translocated to the southern portion of the central California coast.

Task 7 - Aggregation or Translocation

These recovery techniques will be used at the appropriate key locations (Table 6-6).

Task 8 - Out-planting

Black abalone will be out-planted at the appropriate key locations (Table 6-6).

Task 9 - Genetics

A genetics study will be completed to determine if sub-populations exist.

Task 10 - Resistance to WS

Central California black abalone populations will be evaluated for WS resistance.

Table 6-6. Key locations for recovery of **black abalone** in southern California

Area	Block no.	Index	Key location
San Miguel Island	690 & 689		Crook Point to Cardwell Point
	689 & 690	✓	Bay Point to Harris Point
	690	✓	Harris Point to Otter Harbor
	690		Otter Harbor to Point Bennett
	690	✓	Judith Rock to Crook Point
Santa Rosa Island	689	✓	Tecolote Point to Sandy Point
	711	✓	Sandy Point to Cluster Point
	711	✓	Johnson's Lee to Ford Point
	711 & 710		Ford Point to East Point
Anacapa Island	684	✓	Bat Ray Cove to West End
	684		West End to East Fish Camp
Santa Barbara Island	765		Arch Point to Webster Point
	765		Webster Point to Sutil Island
	765		Sutil Island to Sea Lion Rookery
San Nicolas Island	813		All Rocky Intertidal Areas
	814	X	All Rocky Intertidal Areas
Santa Catalina Island	761	X	Long Point to Blue Cavern Cove
	761		Little Harbor to Ben Weston Point
	762	X	Eagle Reef to Stony Point
	762		Stony Point to West End
	762		West End to Ribbon Rock
	762		Ribbon Rock to Catalina Head
San Clemente Island	829	X	Northwest Harbor to West Cove
	849		Little Flower to White Rock
	849 & 850		West Cove south 3 nautical miles
	850	X	Eel Point north 3 nautical miles
	850		Eel Point to Mail Point
	850		Mail Point to Lost Point
	849 & 867		Lost Point to Cove Point
	867		China Point to Pyramid Head
Palos Verdes Peninsula	720		Haggerty's to Lunada Bay
	720		Lunada Bay to Abalone Cove
	719		Abalone Cove to Point Fermin
Dana Point	757		Pelican Point to Laguna Main Beach
	757		Laguna Main Beach to Dana Point
San Diego Area	860		La Jolla (Point La Jolla to Bird Rock)
	860		Point Loma (Mission Bay to Rathay Point)
	860	✓	Point Loma (Rathay Point to Ballast Point)

X - Proposed CDFG index recovery site ✓ - External agency monitoring site

6.6.2.5 White Abalone

White abalone is listed as an endangered species under the federal ESA. Recovery tasks at this time do not involve actual handling of abalone since a special permit is required from NOAA Fisheries.

Task 1 - Exploratory Surveys

White abalone is at an extremely low population level, and most of the recently observed individuals have been large and solitary, which indicates that the population has experienced reproductive failure and is senescent. No recruitment of small individuals was observed during SCUBA or submarine surveys; however, two individuals were observed at Santa Cruz Island (Davis *et al.* 1998). Further exploratory surveys are needed to delineate critical abalone habitat for this species.

Submarine and ROV surveys will take place at Tanner and Cortez Banks due to the greater likelihood of finding white abalone at this location. San Clemente and Santa Barbara Islands will be surveyed due to their proximity to the center of the white abalone distribution area.

Task 2 - Detailed Surveys of Known Abalone Habitat

Data will have already been collected through the video recordings by submersible or ROV surveys during exploratory surveys (Task 1).

Task 3 - Assessing Recovery

Assessment surveys will be conducted at index sites and key locations (Table 6-7).

Task 4 - Develop or Support Existing Culture Programs

Prior to its listing under the ESA, the Department participated in the collection of white abalone for culture, in conjunction with University of California at Santa Barbara, and the Channel Islands Marine Research Institute (CIMRI). A spawn in 2001 produced several hundred thousand progeny which are currently being held at CIMRI until they are at least 100 mm (4 in.) long, at which time they will be out-planted (subject to federal approval). Some of these individuals could also be used to expand the culture program at other facilities. Growing cultured abalone to a large size for out-planting has never been attempted before, and this work should be considered experimental.

While not specifically part of this task, the establishment of alternative culture facilities for growing white abalone would be encouraged. Expanding the culture program would reduce the risk of catastrophic system failure and subsequent loss of the recovery program.

Tasks 5 Through 9

These tasks will not be implemented under the ARMP due to the white abalone's status as a federally listed endangered species. Similar recovery tasks are being conducted under the auspices of the draft federal white abalone recovery plan and the National Marine Fisheries Service. Department personnel are involved in this cooperative effort with the federal government and the private sector.

Task 10 - Evaluation of Resistance to Withering Syndrome

The Department's Shellfish Laboratory may investigate the effects of withering syndrome in white abalone.

Task 11 - Involvement in the Federal White Abalone Recovery Team

Working with this species would involve interaction/participation with the White Abalone Recovery Team, established by NOAA Fisheries. Interaction with NOAA Fisheries on white abalone recovery will establish a direct working relationship with federal agency personnel, which may be useful if other abalone species are listed under the federal ESA.

Table 6-7. Key locations for recovery of **white abalone** in southern California

Area	Block no.	Index	Key location
Santa Cruz Island	685	✓	San Pedro Point to Sandstone Point
Santa Barbara Island	765		Arch Point to Webster Point (Foul Area)
	765	X	Webster Point to Sutil Island
	765		Sutil Island to Grave Canyon
Santa Catalina Island	761	X	Isthmus Cove Area (Ship Rock, Bird Rock)
	761		Long Point to Blue Cavern Point
	762		Eagle Reef to Stony Point
	762		Farnsworth Bank
San Clemente Island	829	X	Northwest Harbor to West Cove
	849		Little Flower to White Rock
	849 & 850	X	West Cove south 3 nautical miles
	850		Eel Point north 3 nautical miles
	850	X	Eel Point to Mail Point
	850		Mail Point to Lost Point
	849 & 867		Lost Point to Cove Point
	867	X	China Point to Pyramid Head
Tanner Bank	872		All Suitable Habitat
	871		All Suitable Habitat
Cortez Bank	890		All Suitable Habitat
	897		All Suitable Habitat

X - Proposed CDFG index recovery site ✓ - External agency monitoring site

6.6.2.6 Pinto Abalone and Flat Abalone

Task 1 - Exploratory Surveys

Exploratory surveys will be completed in conjunction with other exploratory surveys of the five major species.

Task 2 - Detailed Surveys of Known Abalone Habitat

Detailed survey data collected for other species will be used for pinto and flat abalones in areas where they may co-occur.

Task 3 - Assessing Recovery

Assessment surveys will be conducted at index locations (Table 6-8).

Tasks 4 Through 9

These tasks will not be implemented for these species.

Task 10 - Evaluation of Resistance to WS

The Department's Shellfish Laboratory may investigate the effects of withering syndrome in pinto and flat abalones.

Table 6-8. Key locations for recovery of **pinto and flat abalones** in southern California

Area	Block no.	Index	Key location
San Miguel Island pinto and flat abalones	690 & 689	X	Crook Point to Cardwell Point
	689 & 690		Bay Point to Harris Point
	690		Harris Point to Otter Harbor
	690	X	Castle Rock (Otter Harbor to Point Bennett)
	690		Point Bennett to Judith Rock
	690	✓	Judith Rock to Crook Point
Santa Rosa Island pinto abalone	689		Talcott Shoal (Tecolote Point to Sandy Point)
	712		Sandy Point to Cluster Point
	711	X	Cluster Point to South Point
	711	✓	South Point to Ford Point
Santa Cruz Island pinto abalone	685	✓	Cavern Point to San Pedro Point
	685		San Pedro Point to Sandstone Point
	687	X	West Point to Black Point
	687 & 709		Kinton Point to Posa Anchorage
	708	✓	Sandstone Point to Blue Banks
	709	✓	Morse Point to Laguna Harbor (Gull Island)
	709		Albert Anchorage to Laguna Harbor
	709 & 710	✓	Gull Island (Laguna H arbor to Morse Point)
San Diego Area pinto and flat abalones	860		La Jolla (Point La Jolla to Bird Rock)
	860		Point Loma (Mission Bay to Rathay Point)
	860	✓	Point Loma (Rathay Point to Ballast Point)
San Clemente Island flat abalone	867	X	China Point to Pyramid Head

X - Proposed CDFG index recovery site ✓ - External agency monitoring site

6.7 Timelines

There are two timelines in the ARMP, one for the recovery of the abalone resource (presented in this chapter) and one for the implementation of elements of the recovery plan, presented in Section 9.2, Timelines.

Abalone recovery in southern California will probably take many decades. There is doubt whether some species are capable of recovery without human intervention. Many areas where abalone once lived have been without any abalone populations for many years, as a result of local pollution, climatic change, overfishing, and disease. Some of these events continue to occur, making recovery more difficult.

The minimum time for the achievement of Criterion 1 is related to the growth rates of the abalone: faster-growing species will satisfy Criterion 1 more quickly. Red and possibly pink abalones will most likely reach this first level of recovery more quickly than the green, black, and white abalones. The latter two species may take much longer to reach this level because they begin their recovery from very limited populations.

Estimates of time for each species to reach Criterion 1 are given in Table 6-9. The estimates are based on optimum conditions and enhancement activities which would produce the best scenario possible, given the growth rate of each species. The estimates are projections starting from the time recovery activities begin, and do not account for the initial time needed to determine if the recovery activities are worthwhile. Factors such as poaching, El Niños, or other major environmental perturbations will increase the time needed to achieve Criterion 1 levels.

Table 6-9. Estimates for the amount of time for recovery of five species of abalone in southern California. Time estimates for Criterion 1 are based on the estimate of ages at recreational minimum legal sizes.

Species	Criterion 1	Criterion 2	Criterion 3
Red	6-11 yrs [1]	?	?
Pink	14-16 yrs [2]	?	?
Green	14-20 yrs [2]	?	?
Black	20+ yrs [3]	?	?
White	9+ yrs [2]	?	?

[1] Haaker *et al.* 1998
[2] Tutschulte 1976
[3] Haaker *et al.* 1995

For red abalone, the time required to achieve a broad size range may take 6 to 11 years, because the small- and medium-sized abalone will have to come entirely from successful settlement and recruitment every year. This is the absolute minimum time needed to allow newly recruited abalone to grow and fill in the intermediate cohorts of the size distribution. It may take even longer to see increased numbers and size ranges throughout the historic range.

To achieve Criterion 2 and Criterion 3 may take decades, and estimating the time needed to reach them would be purely speculative. Once a species reaches Criterion 1 levels, an estimate of the time necessary to reach the next level of recovery may be possible. Future time estimates for recovery can be added or

revised in the ARMP as recovery progresses and more information becomes available.

6.8 Alternative Approaches to Recovery

During the early stages of resource recovery (before Criterion 1 is met) few alternatives are available (Section 6.2.1.1 Criterion 1 - Broad Size Distribution Over the Former Abalone Range). If early recovery for any given abalone species cannot be demonstrated, the only alternative approach is to propose listing under the federal or state ESA.

Alternately, if recovery progresses successfully, there could be a desire to consider reopening a fishery even though recovery has not reached its goals. Alternate approaches that allow fishing to occur prior to complete recovery (Section 6.2.2.2 Criterion 3 - Fishery Density Level (6,600 ab/ha)) are considered under Section 7.3, Management Alternatives.

6.8.1 Recovery Alternative 1 - Listing of Species That Fail to Recover

If recovery cannot be demonstrated by broadening size ranges or evidence of recruitment throughout a species' former range (Section 6.2.1.1 Criterion 1 - Broad Size Distribution Over the Former Abalone Range), then listing on the state or federal ESA is warranted. Listing would convey extraordinary protection, and perhaps provide further resources to prevent extinction of the species.

Listing under the ESA conveys special protected status to the species at risk, and provides additional resources and funding for further recovery work. Listing endangered abalone species increases public awareness of threats to marine species in general. However, listing under the ESA also increases the possibility of being denied access to the resources and areas occupied by the listed species.