THE ABALONE ADVISORY GROUP REPORT
January 29, 2010

on

MANAGEMENT OPTIONS FOR ESTABLISHING A POTENTIAL RED ABALONE FISHERY AT SAN MIGUEL ISLAND

FOR PRESENTATION TO THE MARINE RESOURCES COMMITTEE OF THE CALIFORNIA FISH AND GAME COMMISSION
FEBRUARY 16, 2010

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In Cooperation with the Abalone Advisory Group

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

Abbreviations	Expanded Meaning
ARMP	Abalone Recovery and Management Plan, adopted by CA Fish and Game Commission in 2005
AAG	Abalone Advisory Group
BACI	Before-After-Control-Impact – An experimental design in which designated control and treatment plots are matched based on similarity. An experimental disturbance is introduced and impacts to the study site are compared against the control site.
BRP	Biological Reference Point
CAA	California Abalone Association
CINP	Channel Islands National Park
Commission	Fish and Game Commission
CPUE	Catch Per Unit of Effort – the quantity of fish caught (in number or weight) with one standard unit of fishing effort. Often considered an index of fish biomass (or abundance)
DFG	California Department of Fish and Game
IFQ	Individual Fishing Quota
MOU	Memorandum of Understanding
MRC	Marine Resources Committee of the Fish and Game Commission
MVP	Minimum Viable Population – minimum density level necessary to protect a population from the risk of collapse in the absence of a fishery
SCA	Statistical Catch-at-Age
SMI	San Miguel Island
SMR	State Marine Reserve
TAC	Total Allowable Catch
TAMC	Total Allowable Market Catch
TOR	Terms of Reference

EXECUTIVE SUMMARY

The Abalone Advisory Group (AAG) is a constituent advisory group formed by the California Department of Fish and Game (DFG) in response to the California Fish and Game Commission's (Commission) direction to consider a process for opening a limited fishery for red abalone at San Miguel Island. This Report describes the AAG recommendations to the Commission regarding options for the potential establishment of a red abalone fishery at San Miguel Island (SMI). This Report also provides a description of the collaborative process and technical underpinnings used to formulate these recommendations.

Charge to the Abalone Advisory Group

The Commission directed the AAG to develop a reasonable range of options for managing a fishery and charged the AAG to make recommendations on four key issues:

1. Total Allowable Catch (TAC) on SMI;
2. Alternatives for allocation of recreational and commercial take of red abalone;
3. Alternative regulations to achieve the total allowable catch and;
4. Potential management, enforcement, and monitoring techniques.

Analytical Support for the Management Options

To respond to the Commission's charge to consider the potential for establishing a red abalone fishery, the AAG worked collaboratively to establish a process for identifying a scientifically based TAC. This effort involved (1) formation of a Technical Panel to carry out data collection and modeling to advise the AAG and (2) selection of a Review Committee to provide peer review of the modeling work. While there is no formal, established review process for DFG's technical work, the peer review approach used by the AAG conveners drew upon several other processes for integrating science and public policy and is similar to other DFG efforts on technical work.

The modeling work used the most recent and reliable data to project changes in the abalone population using different assumptions about complex biologic factors. The AAG relied on the advice of the Technical Panel and Review Committee to inform their management options. The modeling analysis resulted in a preliminary finding that the abalone population on SMI is predicted to decline even in the absence of fishing and also helped to identify and evaluate a suite of Biological Reference Points that may be used to assist with fishery management decisions.

The Review Committee provided suggestions for refining the model and advised that supplemental modeling work is needed to provide a more reliable population estimate over the short-term (5 years) and longer term (10 – 20 years). The Review Committee also advised that an experimental fishery "should be considered" provided the following key preconditions are met: the details of a monitoring plan be specified and agreed to; a power analysis is conducted to confirm that the monitoring will be able to detect effects

of importance and; the modeling methodology should be refined and used in projection mode to estimate a range of possible consequences for SMI abalone abundance at any level of removal. The Review Committee's advice regarding the experimental fishery is based on fishing mortality reference points for red abalone and best professional judgment.

Based on the modeling work and the Review Committee's advice and their best professional judgment, the Technical Panel advised the AAG to adopt a precautionary approach. They suggested the AAG refrain from proposing that a fishery be opened until supplemental modeling work is completed and until a risk analysis, using the proposed TAC and size limits being considered, is performed.

AAG members are in agreement that while the modeling work constitutes the Best Available Science, the work is incomplete, needs refinement and additional information is needed concerning the long-term ability of the population to sustain a fishery. Some members of the AAG are comfortable with the modeling work's short-term conclusion that the current red abalone population is not sustaining itself. Other members of the AAG want to wait until additional long-term projections are completed before making a TAC recommendation. Still other members of the AAG relied upon additional, outside information to support their management option(s).

To respond to the Commission's charge to develop a reasonable range of alternatives, the AAG developed four stand-alone management options for the Commission's consideration (the authors' complete description of each management option is provided in Appendix A). Each of these options was authored by a different subset of AAG members and, as such, collectively represent "a reasonable range of alternatives" consistent with their charge. The AAG was neither asked to screen nor rank the options. These options are intended to be distinct, stand alone options. However, the Commission may choose to combine distinct elements of these options. These options are discussed below and summarized in Table 1 (Summary Matrix of AAG Proposed Management Options).

Fishery Management Option A: "Red Abalone Demonstration Fishery"

This option proposes establishing a demonstration, restricted-access fishery in the Southwest Zone of SMI with an overarching goal of a well-managed, long-term sustainable[1] fishery that continues to rebuild. The initial TAC is 10,728 abalone with a minimum harvest size of 8 inches (203 mm); estimated at approximately 3% of the total

[1] While each of the management options references sustainability as a goal, the AAG members were not asked to, nor have they defined a common definition of sustainability. For reference, the MLMA definition of "sustainable" (Section 99.5) with regard to a marine fishery includes the following: a) continuous replacement of resources, taking into account fluctuations in abundance and environmental variability and; b) securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity and in the case of fishery management based on the maximum sustainable yield, taking in a fishery that does not exceed optimum yield.

emergent population in the Southwest Zone of SMI. The TAC is proposed to be annually evaluated using a yet-to-be developed Decision Tree Assessment Process specific to red abalone on SMI.

Management Option A provides 90% of the allocation to the commercial sector and 10% to the recreational sector. This management option proposes establishment of a commercial fishermen's harvesting cooperative and envisions development of a shared management framework between the state and the cooperative to be described in a Memorandum of Understanding (MOU). Under this option, regulations regarding recreational allocation and fishing would be established and managed by DFG, in consultation with recreational constituents and others.

Fishery Management Option B: "Conditional Demonstrational San Miguel Island Fishery"

This option proposes an initial conservative approach maintaining the current ban on any harvesting of abalone. This option proposes an initial TAC of zero with a conditional TAC of 8,300 abalone, pending completion of supplemental modeling analysis and confirmation that the TAC could be sustainable. Assuming establishment of a future, demonstration fishery, this option proposes an annual evaluation of the TAC. This annual evaluation would consider density surveys, minimum viable population estimates and include advisement to the Commission on identified science and management issues from a reconstituted Abalone Advisory Group.

Management Option B proposes an equal allocation (50%) to commercial and recreational fishing interests. The recreational harvest will be assigned by DFG using an application and distribution process. This option is supportive of assigning the commercial harvest as recommended by the Commission. Under this option, management of the fishery would be retained by the State with revenue from commercial and recreational yields funding the monitoring, enforcement and management.

Fishery Management Option C "Precautionary Experimental Harvest"

This option's main objective is to offer an experimental approach for verifying a TAC while simultaneously creating new population centers from the translocated abalone. Management Option C is silent on whether to open the fishery or what the TAC should be – only that if a fishery moves forward, that the TAC is tested in this manner and any allowed take is used to promote population restoration. Once a TAC is warranted – based on adequate scientific information to conclude that there is a reasonable and sustainable level of yield available in the fishery – it would be implemented using an experimental test in which a defined portion of the TAC, across a small spatial scale, is used to transplant abalone to other designated areas so as to enhance existing stocks. If adequate recruitment is demonstrated, such that abalone populations at SMI do not decline as a result of removal and transplantation, then at a later point, some portion of the TAC could also be directed to consumptive harvesting as needed to fund the restoration effort.

It is proposed that the initial translocation be managed by a non-governmental organization (NGO) (to be identified) so as to not unduly burden DFG, and funded through dedicated state/federal funds, NGOs and/or fundraising efforts. Allocation between recreational and commercial fishermen would be dependent on the need for a revenue stream to fund the translocation.

Fishery Management Option D "Assurance Approach"

The primary goal of this option is to ensure a long-term sustainable population of red abalone at SMI. The authors propose using precautionary principles to protect Southern California's last remaining stronghold for red abalone. Management Option D proposes a TAC of zero as long as population densities are below 4,000 abalone/hectare. If this density threshold is exceeded, then the fishery could be opened using a sustainable TAC, to be determined based on adequate survey data and further modeling. In the event that the density threshold is met and the fishery is opened, any allocations from Options A – C would be compatible with this option. Under this option, DFG would manage the program at its discretion and retain primary oversight over enforcement and monitoring.

Key Recommendations and Future Considerations

The fundamental agreements that arose out of the AAG's collaborative process include:

1. **Recommendation: Use adaptive management to ensure a sustainable abalone population.** Specific fishery management factors to consider are the use of an adjustable TAC that is based on the most current stock assessment and monitoring surveys. AAG members also expressed a strong interest in exploring which fishery indicators, or biological reference points, are most useful for this fishery. The AAG members also recommend increasing the minimum harvest size for red abalone to 203 mm (8 inches).

2. **Recommendation: Improve monitoring sensitivity and data collection to inform adaptive management of the fishery.** Specifically, AAG members suggest that more data collection is needed to help determine the size and structure of the population, as well as provide information on recent recruitment and population increases or decreases. It is also recommended that the precision of the surveys be increased so that surveys are capable of detecting smaller changes in population density.

3. **Recommendation: Proceed with supplemental modeling work.** The AAG has unanimously agreed that supplemental modeling work is needed to make refinements to the model and project the population over longer time periods using different levels of risk. This additional modeling work will improve the

sensitivity (and efficiency) of the ongoing monitoring effort and will better inform the Commission about the long-term ability of the population to support a fishery.

4. **Guidance is needed on moving forward.** AAG members acknowledge that more specificity is needed to implement whichever option(s) the Commission decides to consider or adopt. This will involve direct interactions between DFG and affected constituents.

The Marine Resources Committee (MRC) of the Fish and Game Commission is expected to consider the management options presented in this Report and, in consultation with DFG, make recommendations to the Commission on the appropriate course of action for the red abalone population at SMI. The Commission will also determine whether the AAG has completed its charge and be brought to a close, or alternatively, whether the AAG should continue in some yet-to-be-defined, advisory role in the future.

TABLE 1: Summary Matrix of AAG Proposed Management Options

MANAGEMENT OPTION	AUTHORS	TAC	TRIGGERS	ALLOCATION of TAC	MANAGEMENT FRAMEWORK
Option A: **Red Abalone Demonstration Fishery**	California Commercial Abalone Association: Jim Marshal, Chris Voss	Open fishery in the Southwest Zone with a TAC of 10,728 abalone/year and minimum harvest size of 8 inches	Annual evaluation of TAC based on a prescribed Decision Tree process that incorporates significant biological triggers	Allocate 90% to Commercial Allocate 10% to Recreational	Establish commercial fishing harvesting cooperative. Shared management framework to be described in MOU between fishing cooperative and DFG
Option B: **Conditional Demonstrational San Miguel Island Fishery**	Recreational Fishers: Bill Bernard, Terry Maas	Maintain Closure (TAC of Zero)	Upon completion of supplemental monitoring work, implement sustainable TAC (e.g. 8300) in the South West Zone	Allocate 50% to Commercial Allocate 50% to Recreational	DFG retains fishery management responsibilities in conjunction with a Abalone Advisory Group process
Option C: **Precautionary Experimental Harvest**	Jessie Altstatt, formerly Santa Barbara Channelkeeper John Butler, NOAA Dan Richards, NPS Greg Sanders, Minerals Management Service	No quantitative recommendation. TAC will be experimentally tested. Any TAC initially used solely for restoration by translocating abalone to new locations	Upon demonstration of adequate recruitment, portion of TAC may be allocated to consumptive harvesting	No recommendation on allocation – consumptive harvest dependent upon revenue needed to fund restoration effort	DFG determines TAC and retains fishery management responsibilities. Project could be efficiently managed and implemented by NGO partnership
Option D: **Assurance Approach**	Daniel Geiger, Santa Barbara Museum of Natural History Jessie Altstatt, formerly Santa Barbara Channelkeeper Dan Richards (National Park Service)	Maintain Closure (TAC of Zero)	Open fishery once density exceeds 4,000 abalone/hectare. TAC to be determined based on available survey data and modeling	No recommendation on allocation	DFG retains fishery management responsibilities

INTRODUCTION

This Report describes the Abalone Advisory Group's (AAG) recommendations to the Marine Resources Committee (MRC) of the California Fish and Game Commission (Commission) regarding the potential establishment of a red abalone fishery at San Miguel Island (SMI).

In 2006, the Commission established the AAG and identified four charges: (1) identify a Total Allowable Catch (TAC) on SMI; (2) create alternatives for allocation of recreational and commercial take of red abalone; (3) describe alternative regulations to achieve the total allowable catch and; (4) develop potential management, enforcement, and monitoring techniques.

In response to this charge, the AAG worked collaboratively to establish a process for identifying a scientifically based TAC. This effort involved (1) formation of a Technical Panel to carry out data collection and modeling to advise the AAG and (2) selection of a Review Committee to provide peer review[2] of the modeling work. The modeling work used the most recent and reliable data to project changes in the abalone population using different assumptions about complex biologic factors.

In deliberating on the information provided by the Technical Panel and Review Committee and with the support of Department of Fish and Game staff (DFG), the AAG members developed a range of four alternative management options for the Commission to consider. They are: A) Red Abalone Demonstration Fishery, B) Conditional Demonstrational San Miguel Island Fishery, C) Precautionary Experimental Harvest, and D) Assurance Approach.

At this writing, the modeling work is unfinished and does not yet provide long-term information on potential population abundance. The AAG members agree that while the modeling work constitutes the Best Available Science, the work is incomplete and needs refinement and additional information is needed concerning the long-term ability of the population to sustain a fishery. Some members of the AAG are comfortable with the modeling work's short-term conclusion that the current red abalone is not sustaining itself. Other members of the AAG want to wait until additional long-term projections are completed, and still others relied upon additional, outside information to support their preferred management option. Funding for the supplemental modeling work has recently been identified and the work is projected to commence in early fiscal year 2010.

At its June 2009 meeting, AAG members took stock of their progress and agreed that it was timely to provide a report to the Commission in February 2010. While the AAG members had preferred to complete the needed supplemental modeling work, they

[2] While there is no formal, established peer-review process for DFG's technical studies, the AAG process relied on a method of peer review that is similar to methods used in other DFG studies and is consistent with other joint fact-finding efforts.

agreed it would be timely to describe the management options developed to date. During their December 18, 2009 teleconference, the AAG agreed to present the current findings and management recommendations to the Commission's MRC as an appropriate, interim step.

This Report describes the four management options for a potential abalone fishery and the unique process used to develop them. The AAG process was a cooperative planning approach using a constituent advisory group and joint fact-finding methodology to support the scientific underpinnings of the AAG's recommendations.

This Report also describes the AAG's technical approach. This included use of external scientific expertise to spearhead modeling of the red abalone population with an emphasis on determining impacts to the population associated with re-establishment of a fishery. Finally, the Report identifies key areas of agreement among AAG members and future considerations for the Commission's deliberation.

Background on Abalone Fishery

California Abalone Fishery

The modern fishery for red abalone *(Haliotis rufescens)* in California has existed throughout most of the 20th century, with the peak of commercial fishing occurring in the late 1950s. Landings began to decline in the 1970s and 1980s due to a number of factors, including: the expansion of the sea otter population, which led to the loss of the original Central California fishing grounds; changes in recreational and commercial abalone fishing levels; and the occurrence of a deadly bacterial disease (Withering Foot Syndrome). In 1997, the state of California enacted an abalone fishing moratorium from San Francisco Bay south to the Mexican border.

Figure 1: California Channel Islands National Park. San Miguel Island is the farthest northwest Island. Source: www.aquaviews.net

San Miguel Island (SMI), the most northwest of the Channel Islands in the Southern California Bight, is the center of red abalone abundance in southern California due to upwelling and cold water influx (See Figures 1 and 2). At the time of closure in 1997, the SMI red abalone population was the focus of commercial and recreational fishing activity.

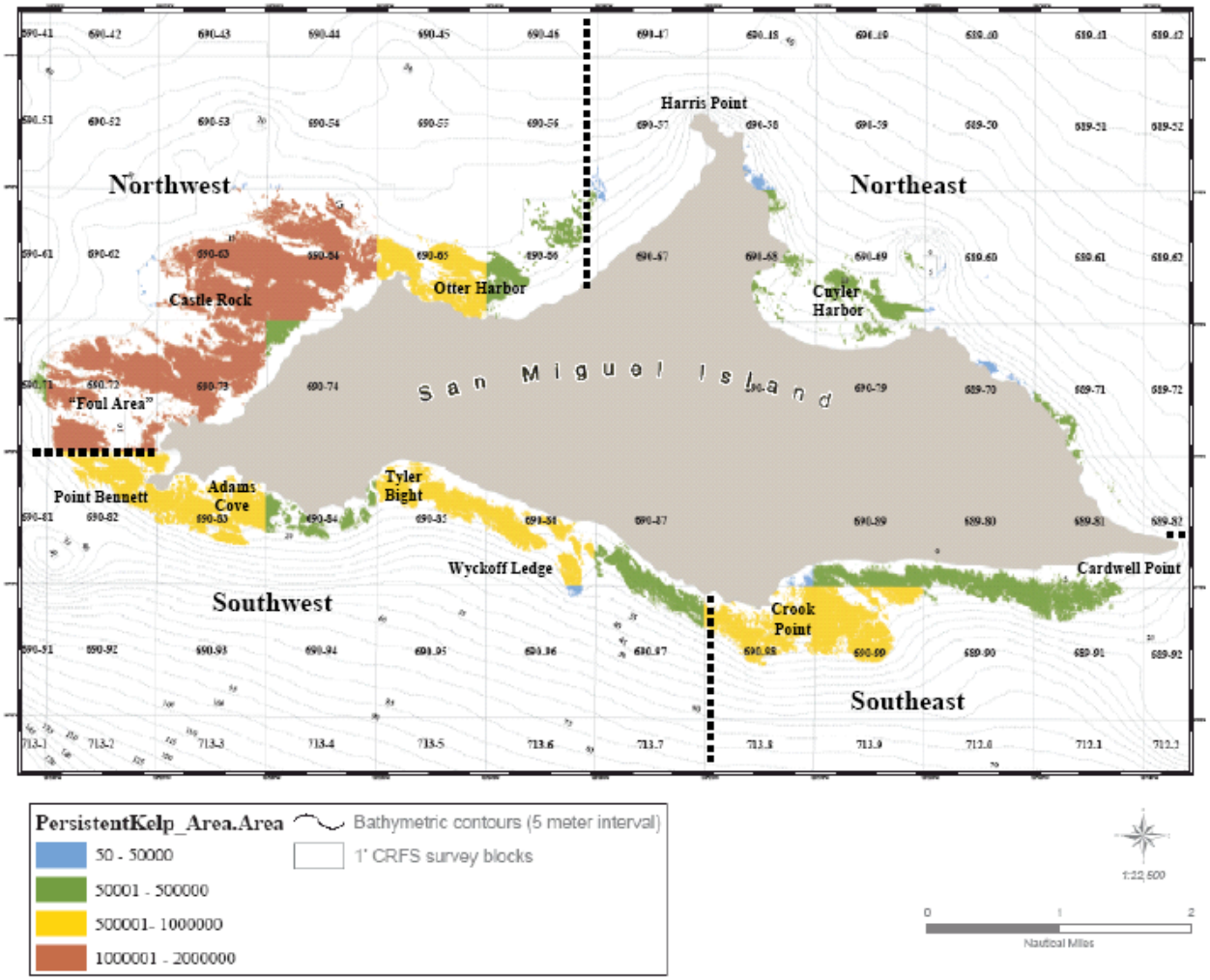


Figure 2: San Miguel Island with persistent kelp cover, survey zones, major landmarks, and anchorages. Source: California Department of Fish and Game.

Abalone Recovery and Management Plan (ARMP)

Mandated by the same 1997 legislation that created the moratorium, the ARMP was adopted in December 2005 by the Commission to manage abalone fisheries and prevent further population declines and guide recovery throughout California. At this time, the Commission also directed the California Department of Fish and Game (DFG)

to begin consideration of a process for opening a limited fishery for red abalone at San Miguel Island (SMI).

Section 6.3.1 of the ARMP allows for consideration of fisheries in specific locations prior to the achievement of full recovery, and identifies the red abalone resource at SMI as the first subject for fishery consideration prior to full recovery. This identification is based on several premises, including: the current existence of a viable population at SMI, with population densities at or near the general minimum viable population (MVP) level of 2000 abalone per hectare; a broad size range in the population at SMI; and the presence of abalone in established no-take reserves at SMI that may help ensure continued abalone populations during potential fisheries elsewhere at the Island.

The ARMP also set a generic MVP threshold estimate for abalone at 2,000 abalone per hectare. This is based, in part, on a studies of abalone densities from southern California, Washington State, and south Australia that suggests populations between 500 – 3,000 abalone per hectare are susceptible to population collapse and recruitment failure.

The most recent surveys conducted by the DFG in 2006[3], 2007, and 2008 (Appendix B) estimated the population density at SMI to be 1,200, 1,100, and 1,500 abalone/hectare, respectively. The total population of abalone at SMI in 2006, 2007, and 2008 were estimated at 910,000, 758,000, and 795,000[4] with maximum kelp area totaling 13,780,000 m^2, 10,470,660 m^2, and 5,061,418 m^2, respectively (DFG 2006, 2007 and 2008[5]). Abalone densities inside versus outside the Judith Rock Reserve were 1,200 and 1,700 in 2006; 1,100 and 1,500 in 2007 and; 1,500 and 1,900 in 2008.

These fluctuations in abalone populations may be partially explained by differences in the areas surveyed each year. For example, the 2006 survey encompassed a wider survey area (up to a depth of 80 feet) while the 2007 and 2008 reduced the survey area. Also in 2008, only the two southern zones were sampled and this is where most of the abalone population resides.

It should be noted that a large-scale survey similar in scope to the 2006-2008 surveys was not conducted when the fishery was closed in 1997. Therefore, there is insufficient survey information to determine at the present time whether the population is stable, increasing or decreasing in the absence of fishing.

[3] These 2006 population estimates were adjusted to align the data with the 2007 population estimates, which only included surveys from stations of < 50ft depth.

[4] CONCUR communications with Ian Taniguchi on November 10, 2009 and December 15, 2009.

[5] CONCUR communication with Ian Taniguchi on November 10, 2009 and December 15, 2009.

BACKGROUND ON FORMATION, PROCESS AND CHARGE OF THE ABALONE ADVISORY GROUP

Charge of the Abalone Advisory Group

The DFG embarked on the fishery management process by applying a cooperative planning approach and impaneling a constituent advisory group, the AAG. Convened in September 2006, the AAG was created by the DFG to directly involve stakeholders in the development of potential fishery options at SMI. Numerous interests were ultimately represented by an 11-member group (Table 2) that was selected by the DFG and the Commission based on professional experience, diversity of perspectives, communication network, capability to work with diverse viewpoints, and commitment to successful completion of the process. The AAG includes stakeholders from commercial fishing (California Abalone Association, or CAA), recreational diving, fisheries science, and marine conservation groups, as well as the representatives from the Channel Islands Marine Sanctuary, Channel Islands National Park, and DFG.

TABLE 2: AAG MEMBERSHIP AND AFFILIATION

Jessie Altstatt	Former Science Director, Santa Barbara Channelkeeper
Bill Bernard	Recreational abalone diver representative
Dr. John Butler	National Oceanic and Atmospheric Administration Fisheries
Dr. Daniel Geiger	Research Curator of Electron Microscopy, Santa Barbara Museum of Natural History
Terry Maas	Recreational abalone diver representative
Jim Marshall	Member, California Abalone Association
Chris Mobley	Superintendent, Channel Islands National Marine Sanctuary
Dan Richards	Biologist, Channel Islands National Park
Greg Sanders	Minerals Management Service
Chris Voss	President, California Abalone Association
Sean Hastings (Alt)	Resource Protection Coordinator, Channel Islands National Marine Sanctuary Alternate to Chris Mobley

The Commission directed the AAG to create *a reasonable range of fully developed options for managing a potential fishery at SMI*. Each option was expected to specifically address four items: 1) a "total allowable catch" for San Miguel Island red abalone; 2) alternatives for allocation between recreational and commercial take; 3) alternative regulations to achieve the total allowable catch and allocation, and; 4) potential management, enforcement, and monitoring techniques.

The DFG will use these management options, alongside the results of the completed modeling work, in making recommendations to the Commission. It is anticipated that an environmental analysis under the California Environmental Quality Act (CEQA) would be conducted prior to adoption of a new management regime for the fishery. While the

AAG's range of management options does not include a "No Action" alternative, any CEQA analysis would include consideration of the "No Action" alternative and an evaluation of the existing TAC and current management under the ARMP.

AAG, Department and Facilitation Roles: Process Overview

Recognizing the complex and potentially divisive nature of the deliberations, the DFG contracted for the services of a facilitation team, led by CONCUR, Inc., in early 2007. The facilitation team supported essential work to update AAG membership, convened a series of plenary and teleconference meetings of the AAG, and guided and synthesized deliberations.

AAG members adopted a set of ground rules designed to promote respectful interaction, integration of ideas, and commitment to the process and participated in small work teams designed to create multi-interest options and work products. The work teams drafted and refined a set of management options for the potential fishery, which addressed allocation options, budget, enforcement and other management options.

The DFG maintained a strong role in the process by supporting facilitation and communication, preparing guidelines for management options, leading the collection of data for modeling, spearheading the modeling development and review, and engaging outside funding sources and experts.

The adopted Ground Rules, summaries of the AAG's key agreements, and discussions during its 12 meetings from September 2006 to September 2009 are provided in Appendix C. Figure 3 depicts the multi-step process used to develop a scientifically-based TAC and inform the AAG's management options. Figure 4 depicts the timeline and specific milestones for the AAG effort.

Figure 3: Overview and Relationship of Entities Involved in Option Development Process for a Potential Abalone Fishery at San Miguel Island

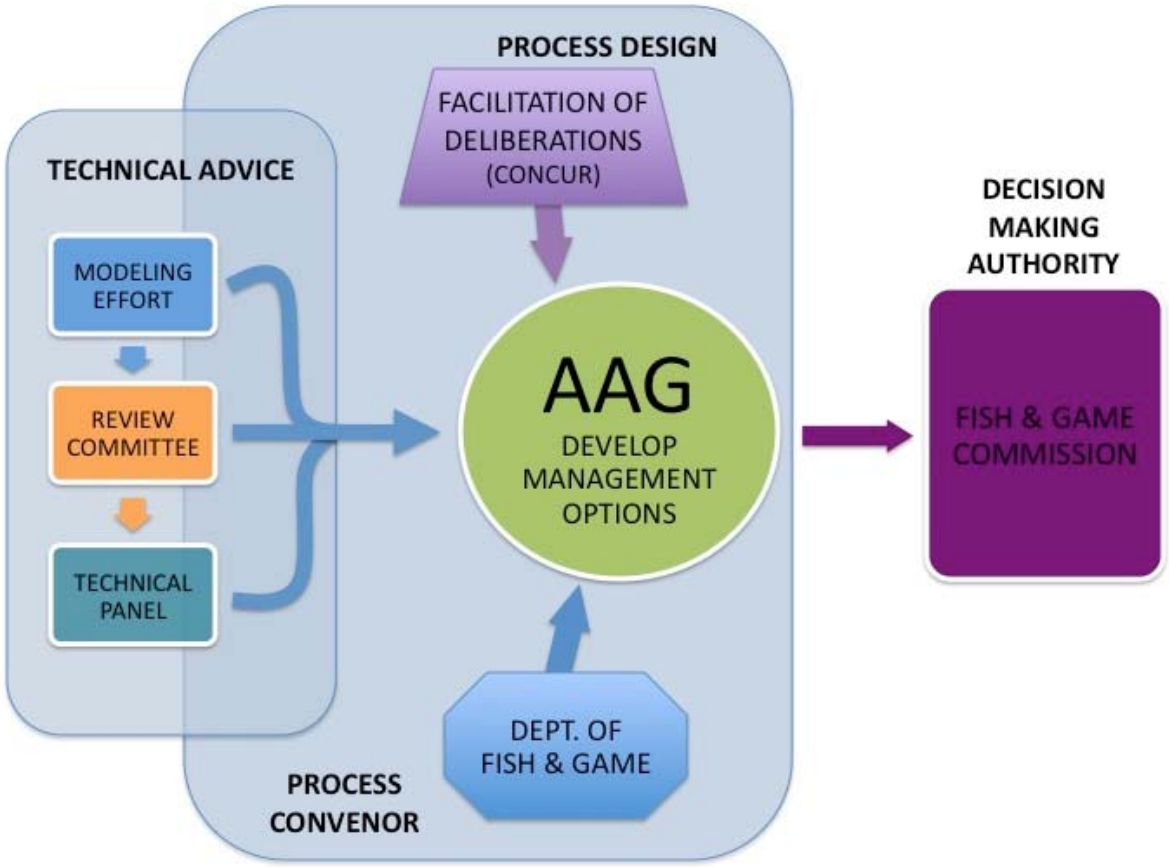
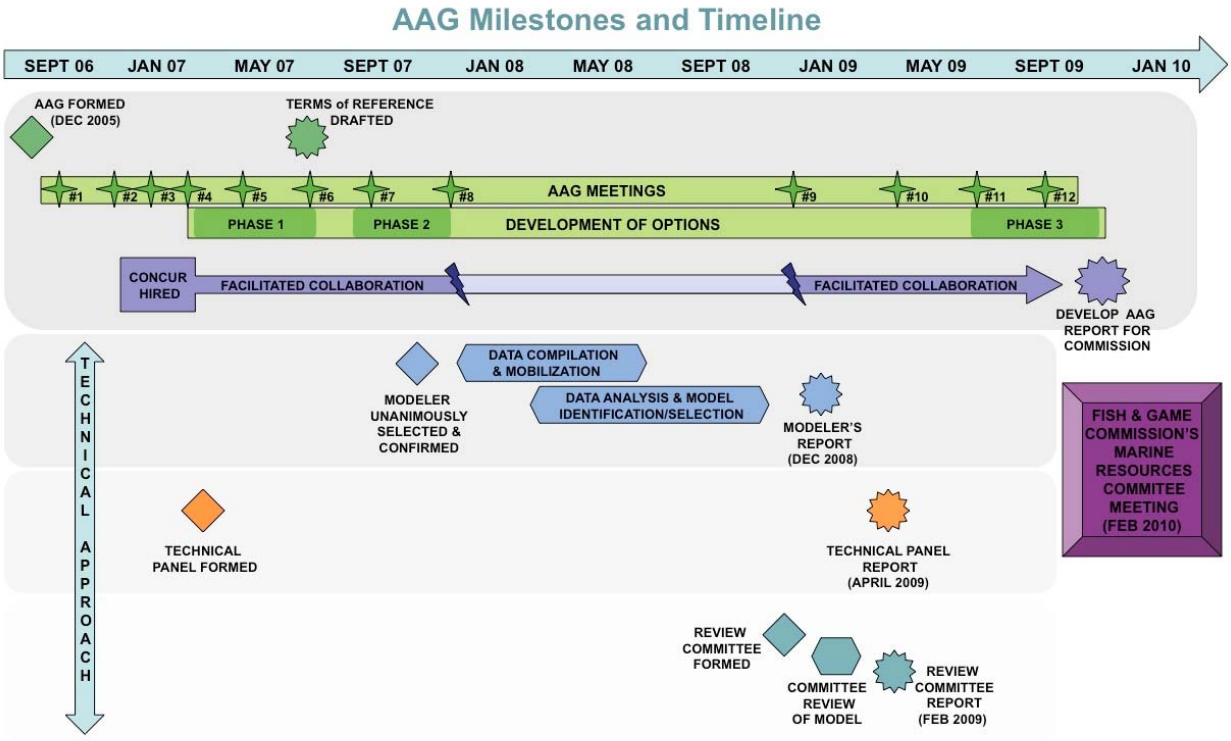


Figure 4: AAG Milestones and Timeline – December 2005 to February 2010



THE ABALONE ADVISORY GROUP'S TECHNICAL APPROACH

Overview of TAC Development Process

To inform and support the creation of its management options, the AAG opted to pursue the development of a scientifically based Total Allowable Catch (TAC) for a potential fishery of red abalone at San Miguel Island. To ensure a well-designed and transparent process, the AAG (1) established a Technical Panel based upon DFG's recommendation and a discussion amongst the AAG member of the proposed members, and (2) selected a Review Committee. A Terms of Reference (TOR) document (Appendix D) was also created, which described the purpose, guiding principles and protocols of the Technical Panel and Review Committee. The Technical Panel and Review Committee consisted of experts with a collective expertise in the fields of abalone biology, marine ecology, fisheries dynamics and modeling, and natural resource policy and management. The Technical Panel and Review Committee members are listed in Appendix E.

Using an AAG workgroup and applying specific selection criteria, the AAG unanimously selected a lead modeler, Dr. Yan Jiao. While the modeling work was originally anticipated to take a few months to complete, the combined need to assemble, collate and format many data sets, and test multiple models – as well as the complexity of

building the model – proved to be a more involved set of tasks than was originally forecast. The net result is that the modeling report was completed 18 months after initiation of the work. The model results report, "Improving the Stock Assessment of California's Red Abalone (Haliotis rufescens) at San Miguel Island" (December 2008), can be found in Appendix F.

While there is no formal, established peer-review process for DFG's technical studies, the AAG process relied on a method of peer review that is similar to methods used in other DFG studies and is consistent with other joint fact-finding efforts. The Review Committee peer-reviewed the methodology and TAC in the modeling report (Review Committee Final Report – February, 2009; found in Appendix G) and suggested refinements. The Technical Panel next produced its final Report, which provided a TAC Framework discussing key considerations and Biological Reference Points for the fishery and a TAC recommendation ("Developing a Total Allowable Catch Framework for Red Abalone at San Miguel Island" April 2009; found in Appendix H).

Abalone Data Inputs

From January to May 2008, extensive data were reviewed and summarized into time series to support population modeling data inputs for red abalone in California. In addition, the DFG conducted cooperative field surveys at SMI in 2006, 2007 and 2008 (DFG 2006 and 2007, 2008). These surveys were designed to provide area-specific abalone density and size frequency information. Vital rates data including growth, reproduction and mortality estimates were examined for red abalone at Santa Rosa Island. Fishery dependent catch data from the past fishery at San Miguel Island were examined from 1950 to the close of the fishery in mid-1997. Many other data sets were also evaluated but not used in the final fishery model runs.

Fishery Model Outputs

The modeling process evaluated the outputs of the potential models (Table 2), explored the relationships identified in each model, and assessed whether the models appear to be stable and precise across different data sets. The models considered for this analysis are described in Table 3, below. The modeler's status updates to the AAG are provided in Appendix I.

Classical stock assessment models were used to assess the risk of population decline based on alternative fishing schemes. The models were projected one year forward and evaluated Biological Reference Points (BRPs). BRPs are fishery resource indicators corresponding to a particular biological state that can be used to provide information on model outputs and guide potential fishery management recommendations. Potential fishing levels (i.e., a TAC) were evaluated across a suite of typical BRPs used in fisheries in conjunction with population abundance estimates generated from the dive-based surveys. The modeling results are described in Dr. Yan Jiao's and Robert Leaf's draft report, *"Improving the Stock Assessment of California Red Abalone Haliotis rufescens at San Miguel Island"* (Appendix F).

This modeling report concluded that the current red abalone population and recruitment levels are still low at SMI, compared to assumed historical levels. Based on the modeling results, the Technical Panel report considered four TAC Options[6]. In every one of the TAC options evaluated and discussed below, the model found a 100% chance that the population will decline in the next year even without harvest.

TABLE 3

CANDIDATE POPULATION MODELS

Population abundance estimation survey – SMI population abundance estimates were made based on surveys of abalone density and size frequency measures in 2006 and 2007.

Hierarchical Growth Model: A von Bertalanffy growth model, based on an extensive tag recapture study, was employed to examine variability in growth over time, as fishery models are typically sensitive to growth rates. The growth model examinations indicated relatively strong annual variation in growth, likely due to slower growth in warm water years. Variation in growth was captured via sensitivity analysis conducted in the catch-at-age and per-recruit modeling approaches.

Statistical catch-at-age/size model – Statistical catch-at-age/size model (SCA) (catch data 1950-1997): This model approach consists of an algorithm derived from historical fishing mortality rates and stock sizes by age, natural mortality, relative abundance indices, and length/age frequency, to produce an operational BRP and TAC which can be used for management.

Yield-per-recruitment model: Both yield per-recruit (YPR) and eggs per-recruit (EPR) analyses were conducted to examine potential BRPs that could be used in fishery management and to set a TAC. These models analyze how growth, natural mortality, and fishing interact to determine the optimal minimum harvest size and fishing mortality rate.

Surplus production model (age-aggregated state-space approach)*: Model Omitted from Further Consideration* - The surplus production model was omitted from the process due to inherent difficulties in estimating critical biological attributes associated with this method, (e.g., starting biomass, intrinsic rate of increase, temporal variation in growth, and maximum sustainable yield (MSY) statistics).

Modeled TAC Option 1: The BRP is derived from the yield per recruit model using 10% of the population above the minimum harvest size (F=0.1) and combined with the 2007

[6] Please note the distinction between the term "Modeled TAC Options" used here and the AAG workgroups' recommended management Options discussed in the section titled "Alternative Management Options Recommended by the AAG."

population survey results. For the model, a size at entry to the fishery of 197mm (former commercial minimum harvest size of 7.75 inches) and the probability of fishing mortality $F>F_{BRP}=30\%$ (fishing mortality greater than the population survey results (308,000 red abalone >197mm) is used to get a TAC of 174,510 red abalone per year.

Modeled TAC Options 2-4: Results from the statistical catch at age model yield a TAC of 22,990 given the BRP used is fishing mortality at maximum sustainable yield and a size at entry to the fishery of 197mm. In this model, a proxy for fishing mortality, F_{msy}, of 0.15 is used rather than the wide range of estimates derived by combining the yield per recruit and the stock recruit models (Shepherd 1982). Since spawning stock size is difficult to estimate and there is a weak relationship between stock size (number of adults) and recruitment (number of juveniles), BRPs derived from this method are not recommended for management.

Alternatively, in cases such as this, Patterson (1992) recommends using empirical reference points, such as the natural mortality rate as a proxy for F_{msy}, which in this case yields a third TAC estimate of 11,120 abalone per year.

Another alternative TAC option is a TAC of zero, despite which the model still finds a 100% chance that the population will decline in the next year.

For each modeled TAC option, the model finds a 100% chance of population decline, even in the absence of harvest. For each TAC option evaluated, the model used an assumption that the abalone population will decline if the density of red abalone falls below 2000/ha. This model also estimates the population forward for only one year and, as such, this model does not reflect the highly variable recruitment rate of abalone.

The Technical Panel Report also identifies a number of critical issues to factor into the development of a well-informed TAC. These considerations are not explicitly included in the fishery models. These additional factors were provided to the AAG to help in its identification of potential BRPs and other fishery management concerns. The issues directly affecting the TAC level are provided in Table 4.

The Technical Panel's Report, *Developing a Total Allowable Catch Framework for Red Abalone at San Miguel Island, April 10, 2009,* and a record of their six meetings can be found in Appendix H and Appendix J, respectively.

Table 4: Principal Issues Affecting the TAC Level

Disease	The abalone disease Withering Syndrome is endemic to southern California waters. Disease surveys indicate that 58% of the population (12% heavy infection) on the island tested positive for the bacteria which causes WS when abalone are stressed with warm water. In the lab, 64% of SMI abalone died when exposed to warm water mimicking the 1997-98 El Niño event. Furthermore, egg and sperm production was drastically reduced in the survivors, with 80% of the females and 88% of the males lacking gametes.
Population Genetics	Genetics work for red abalone at SMI and elsewhere in California is currently underway. Preliminary results suggest that SMI is 98% self-recruiting and that it may be a source population for neighboring islands.
Monitoring Program and Sampling Power	Monitoring programs designed to provide feedback for experimental fisheries are limited by their ability to detect specific effect sizes. In this case, 130 transects are needed in the SW zone to detect a change in density of 30%. This sampling effort would need to increase to 300 transects to detect a smaller effect size of 20% change in density.
Minimum Viable Population Size (MVP)	Minimum viable population size is a minimum value below which recruitment and populations decline. Information on abalone densities from southern California (Tegner et al. 1989), Washington State (Rothaus et al. 2008) and Australia (Shepherd and Brown 1993) suggest that populations below 500-3,000/Ha are susceptible to population collapse and recruitment failure.
Enforcement	Wildlife protection costs for enforcing fishery regulations (size limits, season closures etc.) as well as preventing illegal commercialization needs to be considered. In addition, the remote location and need for enforcement of the MPA will need to be considered in this potential fishery.

REVIEW OF TOTAL ALLOWABLE CATCH DEVELOPMENT METHODOLOGY

Consistent with the analytic process stepped out in the TOR, a Review Committee was appointed to conduct an independent, peer review of the modeling results and methodology. While there is no formal, established peer-review process for DFG's technical studies, the AAG process relied on a method of peer review that is similar to methods used in other DFG studies and is consistent with other joint fact-finding efforts. The results of the peer review aided the Technical Panel in reviewing their methods used in the modeling work and helped the AAG understand the strengths and weaknesses of the modeling work. The Review Committee's comments and suggested refinements are provided in their final report, *Evaluation of the Red Abalone Stock Assessment By the Review Committee In Support of Deliberations of the Abalone Advisory Group, La Jolla, California 17-18 February 200[9]* (Appendix G). The key comments are summarized below.

Overview of Review Committee's Advice

The Review Committee considered the data used in the assessment, the statistical catch-at-age model, and risk assessment considerations. The Review Committee's most foundational advice on the methodology is that the catch-at age model should be modified to incorporate different population trajectories and to assess differing consequences (or risk levels) over a longer time frame (20 years). They also provided advice[7] that an experimental fishery be considered assuming other preconditions were met. Their specific advice is: *"If the approach outlined above for a possible way forward is taken further, there are certain prerequisites to implementation and permitting removal of abalone.*

1. The details of a monitoring program must be specified and agreed to.

2. A power analysis must be conducted to confirm that the monitoring will be able to detect effects of importance, in particular that of reduction in abundance as a result of removals.

3. The statistical catch-at-age assessment methodology should be advanced in line with the advice given above and used in projection mode to estimate the range of possible consequences for SMI abalone abundance of any level of removals that comes under consideration" (*Review Committee's Final Report*, Appendix G).

Model Refinement and Supplemental Risk Assessment

The Review Committee suggested the Technical Panel double check historic catch data to examine trends in landings prior to fishery closure in 1997 and that the model focus on 2006-2008 survey data rather than additional fishery independent survey information. The Review Committee was in agreement with the Technical Panel and

[7] The Review Committee noted that this advice went beyond their designated charge in the Terms of Reference.

strongly confirmed the need for a supplemental risk analysis on the statistical-catch-at-age model. The Review Committee included the following suggestions for refinements to the model and future risk assessment modeling[8]:

- Evaluate risk over short and long time (>20 years) frames;
- Evaluate risk using fixed catch levels initially and then in the future explore fishing, if possible, with feedback controls;
- To refine the model, year class strength projections can be explored sampling from lognormal distributions with mean, variance and first order autocorrelations determined from the previous 20 years of catch records or from other abalone resources;
- Provide more model fit diagnostics to help clarify which elements of the inputs have the greatest influence on the key features of the outputs;
- BRPs can be explored using this risk framework by projecting the statistical catch-at-age (SCA) model forward until the age/size structure stabilizes.

Increased Monitoring Sensitivity

The Review Committee provided a number of suggestions for improving the surveys and monitoring protocols to strengthen density and population estimates. These suggestions focused on issues related to habitat coverage of the surveys, which resulted in revised population estimates from the dive surveys in 2006-2008. They advised that future surveys must have sufficient statistical power to detect biologically important changes in the abundance of abalone. Some specific suggestions offered included: modifying sampling design through stratification of existing data, and optimally allocate sampling effort among strata to permit similar statistical power with fewer transects. Unless a greater number of transects are conducted, modifying the existing survey protocol will only allow for a detection of population changes that are 30% or greater.

Experimental Fishery Approach

The Review Committee's advice to consider an experimental approach for a fishery, contingent on several preconditions, is based on its best professional judgment and standard fishing mortality reference points (rate of 10% per year of animals above the minimum harvest size). No evaluation for this particular abalone population has been made as to the sustainability of this rate or the population trajectory given fishing over time. Its advice regarding an experimental fishery included increasing the minimum harvest size from 197 mm (7.75 inches) to 203 mm (8 inches) and maintaining the Southeast Zone as an unfished control region. Relying on the lower 95% confidence

[8] A complete list of the Review Committee's comments are found in their report included in Appendix G

interval of the population estimate from the 2007 survey, the Review Committee estimated a TAC of 8,300 abalone per year.[9]

The Review Committee framed this advice with inherent assumptions for an adaptive management approach and associated monitoring to inform the decision-making. They advised that experimental fishing (either commercial or recreational) should not occur until all three of the following preconditions are met:

1. *Details of a monitoring program are specified and agreed upon;*
2. *A power analysis must be conducted to confirm that monitoring will be able to detect effects of importance, particularly the reduction in abundance as a result of removals;*
3. *Refine the statistical catch-at-age assessment methodology to include considerations of risk in its projections.*

Finally, the Review Committee suggested revisiting the ARMP's MVP threshold of 2,000 abalone/hectare in light of the apparent population stability.

TAC Framework and Further Risk Assessment Modeling

The Technical Panel agreed with many of the Review Committee's suggestions for refinements to the modeling work and supplemental modeling including conducting a risk assessment. The Technical Panel expanded on the Review Committee's comment to modify the catch-at-age model, and advised that the risk analysis should examine short-term (1 – 5 years) and long-term (10+ years) projections of sustainability given different fishing mortality rates, TACs and size limits. The Technical Panel suggests the risk analysis should be structured to evaluate a range of fishing options including 10%, 5%, 2%, 1% and 0% mortality from fishing.

The Technical Panel agreed that strategies should be explored to improve the power of the sampling in estimating future populations, including modification of transect protocols and inclusion of habitat specific survey information. At the same time, it cautioned that these new strategies may yield only modest improvements.

The Technical Panel suggested that the timing of the start of the experimental fishery be examined. The Technical panel advises that the TAC Framework, risk analyses, BRP, management methods and sampling methods be determined prior to the opening of any fishery. The Technical Panel expressed concern that initiating an experimental fishery in the absence of better monitoring sensitivity or feedback could lead to a population collapse during the experiment at SMI in a region where abalone population densities are low. The Technical Panel further concluded that such impact on the SMI population

[9] This experimental fishery estimate TAC was recalculated to 6,700 abalone per year, using the revised population estimates incorporating habitat specific areas. The revised population estimates are provided in Table 2 of the Technical Panel Report (Appendix H).

could put in jeopardy the spatial recovery of red abalone elsewhere on the island, at neighboring islands, and potentially within the entire region.

In conclusion, the Technical Panel advises a precautionary approach until further risk analysis and modeling can help inform managers in their decision as to whether to open the fishery at SMI and what the TAC should be.

AAG Consideration of TAC and Modeling Work

The advice provided to the AAG by the Technical Panel and Review Committee was formulated after carefully considering a combination of quantitative fishery models, population surveys, abalone biology and best professional judgment. The role of the scientists in this process was advisory. The scientific findings and advice of both the Technical Panel and Review Committee are intended to provide the AAG members with current information upon which to structure their management alternatives.

Members of the AAG came to different conclusions about how to apply the results of the modeling work. The AAG members agree that while the modeling work constitutes the Best Available Science, the work is incomplete and additional information is needed concerning the long-term ability of the population to sustain a fishery. Some members of the AAG are comfortable with the modeling work's short-term conclusion that the current red abalone population is not sustaining itself. Other members of the AAG want to wait until additional long-term projections are completed before making a TAC recommendation. These members agreed that a precautionary approach is the prudent choice. Still other AAG members relied upon additional, outside information[10] to support their management option; these members agreed with the Review Committee's consideration of an experimental fishery that is supported by increased monitoring and adaptive management strategies. These differences in support for the modeling effort and interpretation of the results are reflected in the management options provided in this Report.

There is, however, widespread support among the AAG members that the modeling work should be refined and supplemental modeling work is needed to provide a reliable population estimate over the short term (5 years) and longer term (10+ years). AAG members agree on the need to conduct a risk analysis to assess a range of TAC options and associated risk, and they see these results as important to informing management decisions for the SMI TAC. The entire AAG also supports the need for ongoing data collection. Specifically, more data collection is recommended to help

[10] Other information that was used as the basis for Management Option A is found in the paper, *"A New Beginning for Abalone Management in California: Critique and Comment on the Abalone Advisory Group's Discussions"* by Jeremy Prince and Sarah Valencia – October 2009. This paper was produced outside of the AAG's joint fact-finding process and has not been vetted by the AAG members. This paper is to be provided to the Commission under separate cover.

determine the size, structure of the population, recent recruitment and population increases or decreases.

Collectively, the AAG members have identified the specific modeling work that is needed (see Appendix K for the AAG's proposed description of the supplemental modeling work). However, significant budget constraints have prevented this effort from going forward. Additional funding would also be needed to allow the transfer of this modeling capacity to make it available for use by another researcher or management entity. As of the completion of this report (December 2009), DFG has identified a funding source and anticipates commencing work on the modeling in early 2010 fiscal year.

AAG members also agreed that establishing any fishery would require key feedback from improved monitoring surveys that are capable of detecting smaller changes in population density. Estimates suggest that current sampling, even with stratification, could detect at most 30-50% changes in density. More transects will be needed to increase the monitoring sensitivity beyond such levels. Some AAG members are not confident this level of detection will provide sufficient data to manage the resource. Working in collaboration with DFG, the California Abalone Association (CAA) has developed a revised monitoring protocol in an effort to increase the level of sensitivity and reduce costs to a sustainable level. While this monitoring protocol was initiated in October 2009, it has not been endorsed by DFG and its ability to accurately detect smaller changes in the total population density is unknown.

ALTERNATIVE MANAGEMENT OPTIONS DEVELOPED BY THE ABALONE ADVISORY GROUP

The quantitative fishery models, population surveys and abalone biology, as well as the qualitative advice made by the Technical Panel and Review Committee, were provided to the AAG and used to inform their management options. It is inherent in the AAG's charge to use the findings of the modeling analysis and to interpret the suite of scientific advice to inform their management options. The following set of management options include various recommendations for phasing in a test fishery, fishery allocation schemes, and management and monitoring approaches.

Overview

The AAG recommendations include four management options that have been developed and refined through the entire process to date. A complete description of each management option is provided in Appendix A, as drafted by the AAG authors of each management option. While these options were collaboratively discussed, each of the options was authored by a different subset of AAG members and, as such, collectively represent "a reasonable range of alternatives" consistent with their charge. The AAG was neither asked to screen nor rank the options.

All four of the management options represent a departure from past abalone fishery management practices in that they envision building a management regime around an adjustable TAC, which is based on the most current stock assessment and a risk analysis that considers environmental conditions. The options differ in the proposed TAC and the conditions that must be met to open the fishery. All of the options presented stress the importance of ensuring a sustainable[11] abalone population and carefully managing the resource. Most of the options address considerations of El Niño, Allee effects, small population size and poaching as key concerns to consider when managing the resource. All options also recommend increasing the minimum harvest size to 203 mm (8 inches).

Three of the four options (Options B, C and D) propose to defer any consumptive abalone harvesting until additional information is provided and specific triggers or conditions are achieved. Each of these options proposes a phased implementation for harvesting and determination of the appropriate TAC; either subject to confirmation by additional modeling information and/or attainment of specified triggers.

Option A proposes re-opening of the fishery in the immediate term. It is the authors' intent that this option could proceed even in the absence of additional modeling efforts. This option proposes a demonstration fishery in the Southwest Zone (using an initial TAC that is estimated at 3% of the total population and 10% of those abalone over 8 inches in the Southwest zone). Option A bases its recommendation on the Review Committee's advice to consider an experimental fishery if certain preconditions are met and other outside information[12]. Option A proposes to use a specific approach - Decision Tree Assessment Process - to determine future adjustments to the TAC.

In varying degrees, all of the options are supportive of using a cooperative management framework involving the fishermen as co-managers of the resource; sharing in the data collection and monitoring, and embracing a new system of tracking harvested animals to help ease the enforcement burden for conducting such a fishery. The options show limited similarities in their intended funding sources and regulation changes needed to manage the resource.

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[11] While each of the management options references sustainability as a goal, the AAG members have not defined a common definition of sustainability. For reference, the MLMA definition of "sustainable" with regard to a marine fishery includes the following: a) continuous replacement of resources, taking into account fluctuations in abundance and environmental variability and b) securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity and in the case of fishery management based on the maximum sustainable yield, taking in a fishery that does not exceed optimum yield.

[12] Other information that was used as the basis for Management Option A is found in the paper, *"A New Beginning for Abalone Management in California: Critique and Comment on the Abalone Advisory Group's Discussions"* by Jeremy Prince and Sarah Valencia – October 2009. This paper was produced outside of the AAG's joint fact-finding process and has not been vetted by the AAG members. This paper is to be provided to the Commission under separate cover.

The options also differ in their proposed allocation of the allowed catch between commercial, recreational, and restoration uses. Finally, each option has suggestions for triggers to be used to indicate when the TAC should be adjusted, demonstrating the AAG's common interest in exploring the use of fishery indicators, or Biological Reference Points, for managing the fishery. A matrix summarizing the four management options is provided below in Table 1, as part of the Executive Summary.

Fishery Management Option A: "Red Abalone Demonstration Fishery"

This option proposes establishing a demonstration, restricted access fishery in the Southwest Zone of SMI. In the near term, an initial TAC of 10,728 is set using a Decision Table[13]. An annual evaluation of the TAC and the health of the population are evaluated using a Decision Tree Assessment Process[14]. Under this management option, this fishery is supported by a fishermen's harvesting cooperative, which includes the establishment of a fine-scale harvest plan linking allocation to specific harvest blocks, and the collection and sharing of monitoring data. Populations in the Northwest, Northeast and Southeast Zones as well as in the Judith Rock Marine Reserve in the Southwest Zone will remain as non-harvest areas.

a. **Goals & Objectives:** The overarching goal is a well-managed, long-term sustainable fishery at SMI as well as a healthy red abalone population that continues to rebuild. Other goals are to: 1) provide a means to match the level of effort in a fishery to the health of the fishery resources; 2) promote a sustainable fishery and give fishery participants a greater stake in maintaining sustainability; 3) provide a mechanism for funding fishery management, research, monitoring, and enforcement activities; 4) maintain long-term economic viability in a fishery; 5) provide long-term social and economic benefits to the state and fishery participants and; 6) provide for an orderly fishery while expanding opportunities for the commercial fishing industry to share management responsibility with the DFG.

b. **Total Allowable Catch (TAC**): This management option proposes an initial TAC of 10,728 abalone with a minimum harvest size of 8 inches (203 mm). This TAC is estimated to be approximately 3% of the total emergent abalone population in the Southwest Zone and is 10% of the population **larger than 8 inches** in the Southwest Zone. The TAC estimate is based on 2008 SMI survey data and assumes a 95% probability that the population estimate is equal to or greater

[13] An explanation of the Decision Table design is found on page 19 of the "Red Abalone Fishery Market Operating Guidelines" (included in Appendix A).

[14] A summary of the Decision Tree Assessment Process is found on page 37 the "Red Abalone Fishery Market Operating Guidelines" (included in Appendix A). The Decision Tree Assessment Process has been used and peer reviewed in other areas. The Decision Tree Process for SMI's red abalone population is in development and has not yet been peer reviewed. The work performed on the SMI Decision Tree Assessment Process was conducted outside of the AAG's joint fact-finding effort and has not been vetted by the AAG members.

than 320,220 abalone in the Southwest Zone. This population estimate is derived from a statistical forecasting methodology termed a "bootstrap analysis[15]". The Review Committee used 2007 population data to determine a suggested TAC of 8,300. Surveys of abalone populations found fewer individuals in 2007 than 2008, thus the TAC proposed by the Review Committee is less than the TAC proposed in this option. However, the percentage of harvest proposed in this option is consistent with the Review Committee's suggestion that a take of 10% of the population with a minimum harvest size of 8 inches in the Southwest Zone would provide a viable harvest and still leave 90% of the available stock.

c. **Information and Assumptions Used to Identify TAC:** This TAC is based on the Review Committee's advice[16] (Appendix G) that an experimental fishing program be considered and that a 10% proportional take (for a size limit of 8 inches) is consistent with the Review Committee's advice that this take is below standard fishing mortality reference points. The authors identified the following precautions imbedded in this option: 1) an increased size limit; 2) a conservative TAC with 95% probability that it represents 10% of abalone over 8 inches; 3) elimination of incidental mortality of sub-legal abalone by only handling emergent abalone that can be easily measured; 4) harvesting 30% or less of abalone in a group to protect spawning aggregations and prevent potential Allee effects and; 5) use of a conservative population estimate based on data from non-invasive survey protocols that do not detect cryptic abalone.

This management option is consistent with the Review Committee's experimental fishery advice to increase the minimum harvest size to 8 inches, and base the TAC on 10% of the abalone population over the new minimum harvest size. The Review Committee also identified three preconditions for establishing an experimental fishery[17]. This management option is intended to meet two of the Review Committee's identified preconditions for an experimental fishery including: 1) establishment of an agreed-upon monitoring program and; 2) confirmation that monitoring will be able to detect effects of importance in the population. The CAA has developed a revised monitoring protocol for abalone on SMI designed to increase the level of sensitivity and reduce costs of monitoring. While continuing to work collaboratively with DFG, this monitoring protocol has not yet been endorsed by DFG. The first sampling event for this methodology

[15] The explanation of the bootstrap analysis method may be found in a paper entitled, *"A New Beginning for Abalone Management in California: Critique and Comment on the Abalone Advisory Group's Discussions"* by Jeremy Prince and Sarah Valencia – October 2009. This paper was produced outside of the AAG's joint fact-finding effort and has not been reviewed or vetted by the AAG members. This paper is to be provided to the Commission under separate cover.

[16] Before an experimental fishery is established, the Review Committee set forth the following conditions: 1) establish an agreed upon monitoring program; 2) confirm that monitoring will be able to detect effects of importance in the population and; 3) modify the catch-at-age model to incorporate projections and estimate range of consequences for changes in abalone abundance.

took place on SMI in late October 2009 and is intended to serve as the baseline for the new survey data. Designers of the new protocol intend to achieve the power to detect a 20% change in population; the actual sensitivity of the new survey methodology is unknown at this time. The authors of this option view the methods of collection and analysis of data as part of the overall adaptive management of this fishery and seek to update and follow advances in abalone fishery management.

Although the authors of this management option agree that there should be improvements to the statistical catch-at-age model[18], they do not believe the fishery consideration process should be delayed further due to the lack of funding to perform the modeling work. In this respect, this management option does not meet the Review Committee's final precondition – refine the statistical catch-at-age assessment methodology to include considerations of risk in its projections – for opening an experimental fishery.

d. **Phased Implementation and Triggers for Adjusting TAC:** This option proposes that the TAC be evaluated annually using fishery dependent and independent data and evaluating both fished and unfished areas. Under this management option, determination of the health and long-term abundance of the population are based on a method termed the Decision Tree Assessment Process. The Decision Tree Assessment Process is used to set the annual TAC so as to achieve long-term target abundance, and allows for a TAC of zero if identified triggers are exceeded. The state (DFG) will use the Decision Tree Assessment Process and assigned triggers to determine if continued fishing is warranted, at what levels and adjust the TAC in response to BRPs.

The specific BRPs identified in the Decision Tree Assessment Process will be determined by working with fishery scientists to finalize a Decision Tree Assessment Process specific to red abalone on SMI. The conceptual model will be based on ecological triggers such as sea surface temperature, kelp availability, long-term abundance targets, population size structure and spawning potential. If thresholds for certain triggers are met (such as increased ocean temperature or increased percentage of diseased abalone), the Decision Tree will trigger a zero TAC until the data collected supports a finding that the population is capable of sustaining harvest again. For example, if a disease outbreak occurs, fishing can be curtailed or terminated to ensure that all surviving spawning abalone are preserved to rebuild the stock following the outbreak.

[18] A discussion of concerns with the modeling effort can be found in a paper entitled, *"A New Beginning for Abalone Management in California: Critique and Comment on the Abalone Advisory Group's Discussions"* by Jeremy Prince and Sarah Valencia – October 2009. This paper was produced outside of the AAG's joint fact-finding process and has not been vetted by the AAG members. This paper is to be provided to the Commission under separate cover.

e. **Allocation Among Users:** This option provides 90% of the allocation to the commercial sector and 10% to the recreational sector. Under this option, a commercial abalone harvesting cooperative would be established. All individuals who held an abalone diving permit in the 1996/97 fishing year would be invited to join the cooperative. The Total Allowable Market Catch (TAMC) would be divided equally among all participating members of the cooperative. The long-term capacity for this fishery is proposed at 35 permits. The commercial abalone permits would be transferable based on rules set by DFG. Annual allocation of a TAMC to the cooperative would be reviewed based on the cooperative meeting stated obligations each year. Regulations regarding recreational allocation and fishing should be established and managed by DFG, in consultation with recreational constituents and others. Further information on the cooperative is provided in the additional information for this Option *("Red Abalone Market Fishery Operating Guidelines"*) in Appendix A.

f. **Management Framework (Funding, Monitoring, Enforcement and Regulatory Issues):** This option envisions development of a shared management framework between the state and the cooperative to be described in a Memorandum of Understanding (MOU). Under this shared management framework, the state will be responsible for: 1) setting the TAC; 2) providing licenses and permits and; 3) evaluating the fishery and cooperative performance through an annual review process.

Under this management option, the harvesting cooperative will: 1) take responsibility for directing specific harvest and data collection activities including providing an annual report; 2) ease the burden to the state associated with enforcement and; 3) assist with data management including providing spatially explicit harvest information for refining management approaches. In addition the cooperative will: 1) educate the fishing community on responsible marine resource stewardship and; 2) create a cohesive and motivated community of market abalone divers that will respond wisely to the challenges of sustainable fisheries management.

The cooperative will provide an annual report to include: 1) population trends over time; 2) data collection and research; 3) fishery dependent data; 4) enhancement; 5) revenue generated from the fishery; 6) management costs and; and 7) documenting compliance with terms and conditions of any MOU(s) executed between the cooperative and the state.

Enforcement Approach**:** This option proposes a comprehensive state and community enforcement approach with tags and tracking as the cornerstone of monitoring, management and enforcement. The overall approach includes: a) tag tracking system; b) single port of landing; c) season restrictions; d) harsh penalties; e) vessel identification/monitoring systems and; f) a web-based automated database to establish a chain of custody and trace abalone through

the entire supply chain. Trace Register is currently being proposed as the independent, third party "registry". The cooperative would enforce its community bylaws on its members as well as aide and assist in enforcement of state regulations. The cooperative would implement an "Island Watch Program" within the existing commercial fisheries to look for suspicious behavior by commercial and recreational vessels. A cooperative-funded reward program for information on poaching might also be considered.

Monitoring & Data Collection: Under this option, the CAA and the cooperative would work with DFG to collaboratively train fishermen and design monitoring surveys. This option intends to include fishery independent survey data and fishery dependent data. Specific monitoring information would address: 1) BRPs; 2) spatial distribution; 3) size frequency and; 4) densities in both fished and unfished areas. This data will provide detailed information regarding the fisheries' impact on population growth, and feed the yearly Decision Tree Assessment Process to set the TAC. The 2009 survey protocols use a Before-After-Control-Impact (BACI) experimental design to monitor population trends at specified areas of SMI. This design is proposed to reduce costs and the density information can be used for setting future fishery parameters. Also, each fisherman in the cooperative would be required to complete a "Red Abalone Harvest Log" page for every harvest dive. These Harvest Logs will provide fishery dependent data that can be used to track the total allowable market catch (TAMC), determine catch-per-unit-of-effort (CPUE), and enhance understanding of spatial distribution to assist in managing the resource. This management option proposes that the recreational community be required to meet the same harvest monitoring program standards and obligations as the commercial community.

Funding Mechanisms**.** It is proposed that the MOU between the cooperative and the state would describe the economic responsibilities and obligations of the cooperative. One goal of the cooperative will be to reduce DFG costs and create its own revenue stream to pay for education and fishery-related monitoring and enforcement. Exact cost and revenue streams need to be further clarified. The cooperative would refine current cost and revenue estimates through direct consultation with DFG and the results of the Bren School project "Optimal Design and Management of a Commercial Fishing Cooperative for the San Miguel Island Red Abalone Fishery" ("*Red Abalone Market Fishery Operating Guidelines*").

Key Regulations Needed. Specific regulations needed to manage the TAMC are described in Appendix E of the "Market Red Abalone Fishery Operating Guidelines". These regulations include:
1) seasonal restrictions;
2) 8 inch size limit;
3) harvest zones;
4) restricted access;

5) gear requirements;
6) landing receipts;
7) taxes and licensing;
8) tamper proof tags;
9) additional regulations regarding the cooperative's ability to receive an allocation and;
10) the content of the necessary MOU(s) that outline the cooperative's responsibilities would also need to be developed.

Fishery Management Option B: "Conditional Demonstrational San Miguel Island Fishery"

This option proposes an initial conservative approach maintaining the ban on any harvesting of abalone. Pending completion of risk assessment modeling work that demonstrates assurances for the continued stability, recovery and protection of the abalone population, a limited, demonstration fishery in the Southwest Zone may be established. This fishery would be limited entry and strictly managed to ensure populations do not drop below the minimum viable population (MVP), as established in the ARMP, and overall recovery continues. Management of the fishery is retained with the state with advisory input provided from a reconstituted stakeholder body and using recreational and commercial tags as the cornerstone of the management framework.

a. **Goal**: A demonstration fishery that achieves a sustainable population at low density populations, not necessarily an [economically] viable fishery.

b. **Total Allowable Catch (TAC**): Initial TAC of zero. A conditional TAC of 8,300 abalone is suggested as a probable estimate of the TAC. Any TAC used for a conditional fishery must be substantiated by completion of additional risk assessment and modeling work and/or field data collection confirming the TAC as sustainable. This conditional fishing would occur in the Southwest zone only.

c. **Information and Assumptions Used to Identify TAC**: The initial TAC of zero is based on the following considerations: 1) low population densities of red abalone at SMI; 2) biological concerns and considerations relating to the presence of Withering Syndrome agent within the abalone stocks; 3) the modeling report, "*Improving the Stock Assessment of California Red Abalone at San Miguel Island"* (Appendix F), which concluded that there is a high probability that the population will keep decreasing even if there is no fishery; and 4) genetic research related to the AAG process and key findings suggesting that recruitment is highly localized and that the chance of outside recruitment is rare.

Under this option, the TAC would be determined based upon the results of additional modeling and risk assessment. If upon completion, the data show that current abalone populations can support a sustainable fishery, the management option proposes 8,300 as a probable TAC for the demonstrational fishery. This is based on the Review Committee's advice that "an experimental TAC of 8,300 red

abalone would provide a viable harvest while leaving 90% of the available stock" (abalone with minimum harvest size of 8 inches). If modeling and risk assessment data concludes that a TAC above or below 8,300 is more appropriate, this option would support the implementation of the TAC determined by data results. Regardless of the actual number, the specific TAC would not be implemented until the additional modeling work and risk assessment and/or data collection is conducted.

d. **Phased Implementation and Triggers for Adjusting TAC**: Assuming future modeling results and/or data collection support establishment of a demonstration fishery, the Commission would annually review the TAC and consider MVP information and recent density surveys. If the Commission (with input from a reconstituted stakeholder body) makes a finding that the population has fallen below the MVP threshold or identifies a BRP that indicates negative parameters for the success of a fishery or negative parameters for the resources as a whole, the fishery would automatically be closed or not start at all. It is proposed that a reconstituted AAG rely on an annual review of the TAC and to make recommendations to the Commission. The range of factors to consider includes: 1) a working risk assessment model with various TAC inputs (i.e. 0 to ∞) will be used to determine whether the abalone populations in the Island's southwest and southeast zones are stable, increasing, decreasing, or at risk of collapsing; 2) requirements for a minimum harvest size of 8 inches; 3) ocean temperatures likely to cause manifestations of Withering Foot Syndrome will result in a suspension of the fishery, pending an assessment period; 4) insufficient, measured growth rates of the abalone populations, in the fished and unfished areas, that do not support a TAC or allow for the continued recovery of the abalone populations will result in a zero TAC; 5) insufficient frequency of surveys to improve the power analysis of the risk assessment modeling in a on-going fishery, will lead to a zero TAC; 6) gonad indexing findings that show reduced reproductive capability would adjust the harvest season or suspend harvest until such indexing findings suggest otherwise; 7) the use of the SMI decision tree as an informative tool, not as a decision device; 8) poaching/enforcement threshold considerations – should it be determined that any recreationally harvested abalone (either from SMI or northern California) have entered the SMI market abalone sector, an automatic suspension of the fishery would be occur.

e. **Allocation Among Users:** Allocate 50% TAC to recreational and 50% to commercial users. It is proposed that the DFG assign the recreational harvest using an application and distribution process (comparable to the system used for hunting of deer or big horn sheep). This option is supportive of assigning the commercial and recreational harvest as recommended by the Commission.

f. **Management Framework (Funding, Monitoring, Enforcement and Regulatory Issues):** Management of the fishery would be retained with the State. However, a reconstituted version of the AAG would be established to

provide advisory input to the Commission on issues deemed appropriate and relating to the operation of a recreational and commercial demonstration fishery. This advisory body is recommended to consist of recreational and commercial consumptive representatives, non-consumptive representatives, and Department of Fish and Game abalone resource and science management.

This option proposes using a commercial and recreational tag system for the take of red abalone similar to the system used to manage the Northern California fishery. For recreational users: the tags would (1) designate the number of user and (2) provide printed instructions as to the harvest location and harvest rules, allowed daily catch and bag limits and seasonal closure. For commercial users: tags would designate location and amount of harvest; individual fishing quota (IFQ) single point of landing will be used to manage the resource. This option also proposes that commercial landings be allowed in Santa Barbara only and that the size limit be changed to 8 inches (203 mm).

Monitoring & Data Collection: This option intends to include fishery independent survey data and fishery dependent data. Data would be provided by the tag system (as entered in log books or abalone landing cards for both the recreational and commercial interest). The logs and cards would capture information including: grid area fished, GPS latitude and longitude at the beginning and completion of each dive, time spent harvesting, length of each abalone harvested, number of abalone harvested, weight of abalone, and estimate of abalone left un-harvested and status of aggregations. These logs would also include habitat observations including: bottom type/relief, algal cover, water temperature, and current direction. Monitoring should be conducted per the advice of the Review Committee, using a methodology that can detect changes in abundance resulting from removals.

Funding Sources: For this option, the revenue from both commercial and recreational yields would fund the monitoring and management of the proposed fishery. As a possible estimate of funds, the northern California recreational fishery yields approximately $750,000/year. Additional taxes and permit fees could also be considered.

Key Regulations: The following regulations are proposed:
1) appropriate changes to the F&G code and Title 14 defining the methods, gear, season, area, and daily bag and yearly limits of harvest for recreational and commercial, as well as methods for collection of fishery revenue for management;
2) possession limits and controlled rate of extraction developed and defined for the commercial and recreational interest and;
3) applicable regulations developed addressing marketing, transportation and holding tanks related to preventing the potential spread of WS to the northern stocks of abalone from SMI abalone fishery stock.

Fishery Management Option C "Precautionary Experimental Harvest"

This option emphasizes using a novel, experimental approach to verify the appropriateness of a TAC while using the harvested abalone to create new population centers elsewhere. This option is silent on whether to open the fishery or what the TAC should be – only that if a fishery moves forward, that the TAC be tested in this manner and that any allowed take is initially used to promote population restoration. If the first experimental phase proves successful, then a consumptive harvest could begin under phase two. The experiment would yield information to be used by DFG in rebuilding this and other abalone populations. At the same time, long-term monitoring would elucidate the sustainability of harvest rates under a TAC.

a. **Goal & Objectives**: The goal of this management option is to provide an opportunity to rebuild the stock of reproductive red abalone across the historic range in Southern California. This conservative approach is intended to simultaneously test re-opening the fishery while furthering the goals of the ARMP. This option also offers a precautionary approach to experimentally test the appropriateness of a TAC and new management techniques to ensure against recruitment failure and population collapse.

b. **Total Allowable Catch (TAC**): This option does not propose a specific TAC for two reasons: 1) more modeling information and/or data collection is needed to make an informed decision about a TAC, and more importantly 2) this option emphasizes the importance that any TAC be implemented on an initial experimental basis using a method that does not reduce the current spawning stock and reproductive potential.

c. **Information and Assumptions Used to Identify TAC:** Under any option, a TAC is warranted when population monitoring, scientific review and DFG's risk assessment show that there are surplus abalone that can be fished without endangering the population or adversely affecting recovery. The current modeling information indicates that even with a TAC of zero, the population is declining. However, it is possible, as suggested by the Review Committee, that more appropriate and revealing data analysis could be done to guide decision-makers. It is also possible that additional field data could help determine the actual size structure of the population, whether there has been any recent recruitment, and whether the SMI population appears to be declining or increasing over time (even in the absence of harvest). This option presents the most conservative approach for proceeding with a fishery when a TAC has been identified.

d. **Phased Implementation and Triggers for Adjusting TAC:** Upon determination of a TAC, the proposal suggests that a subset of the TAC (25-50%) be harvested for translocation of the abalone to assist with the rebuilding of other population

centers[19]. Any harvesting is restricted to the southwest Zone. This option proposes that the number of abalone harvested and translocated will ultimately be determined by available funding. Commercial fishermen and/or other qualified divers would be compensated for harvesting and relocating the abalone. Annual monitoring of the population levels at both the donor and translocation sites would be used to determine if the TAC is shown to be sustainable and allow for continuing recovery. All harvest would cease upon any signs of recruitment failure or population collapse or events likely to initiate wide-scale mortality (such as El Niño events). As per the ARMP, this option proposes the fishery be closed and re-evaluated if populations drop below the MVP. A formal review of the fishery would take place every 5 years. Population centers would be monitored for survival and eventual reproduction and recruitment.

If the designated TAC is shown to be sustainable, then Phase 2 would commence, allowing harvest of the TAC (or a portion of the TAC) for landings/consumptive purposes. The Commission may decide to retain a portion of the harvest allocation for continued rebuilding of depleted stocks. Revenues from the landings would be used to fund the transplantation efforts as needed.

e. **Allocation Among Users:** Phase 1: First 5 – 10 years, 100% of TAC allocated to translocation (restoration) efforts. The commercial sector (and others as appropriate) would be engaged in the cooperative fishery research and paid a fair wage to conduct harvesting and repopulation efforts. If a consumptive fishery is opened (Phase 2), this option allows for allocation between recreational and commercial fishermen based upon the Commission's determination. It is anticipated that the take allocation would be dependent on the need for funding sources.

f. **Management Framework (Funding, Monitoring, Enforcement and Regulatory Issues):** Recognizing that DFG resources are limited, a non-governmental organization (NGO) could manage the data collection efforts and produce the reports for evaluating the experimental TAC. This option proposes that DFG make decisions on the actual TAC and management of fishery. Enforcement needs would necessarily increase when the consumptive fishery opens, especially to offset potential poaching. Opening the fishery with this precautionary approach may help reduce the threat of poaching. Revenue from commercial and recreational yields would fund monitoring, enforcement and management. If the costs of managing the fishery cannot be met in this manner, then the decision to open a fishery should be re-evaluated.

Monitoring & Data Collection: Under this option, monitoring would be conducted to detect changes in population resulting from harvest/relocation and to distinguish from naturally occurring mortality (including mortality from El Niño

[19] Translocating a subset of the TAC is recommended solely because of the cost of translocating a large number of abalone.

events). The DFG would evaluate the data every 5 years to determine if the TAC should be adjusted. It is suggested that the monitoring needs be designed so that there is a high confidence level of discerning biologically important changes in population levels. The 2006–2008 surveys had the power to detect 30–50% population change. This option proposes the ability to detect at least a 20% change in population. The new population centers would be monitored for survival and eventual reproduction/recruitment. The receiver areas are to be re-visited after the translocation, (e.g. intervals of 1,3, 6, 12 months after transplanting, and then yearly after the first year). Proposed indicators of success for translocation include: number of abalone transplanted, survivorship, growth and reproduction/recruitment. Other indicators such as larval recruitment may be used, in conjunction with DFG's abalone Recruitment Modules.

Funding: This option proposes securing funds for Phase 1 through dedicated state and/or federal funds, conservation organizations and/or fundraising efforts. Based on previous and ongoing efforts by DFG, the cost of translocation is estimated at $100,000 per 500 abalone. An NGO may provide similar efforts at a lower cost. For Phase 2, the receipts from consumptive harvesting could be used to fund the translocation effort and other activities associated with re-opening the fishery.

Key Regulations: The following regulations are proposed:
1) a larger size at harvest, 8 inches (203 mm);
2) a limited season for ease of enforcement;
3) single port of entry once in Phase 2;
4) automatic closure mechanisms with forecast of El Niño or at the first signs of a significant Withering Foot Syndrome epidemic;
5) mandatory reporting requirements with abalone tags (with fines for not reporting) and mandatory collection of metadata with commercial permits and;
6) management elements of the cooperative fishery identical to those proposed in Option A.

Fishery Management Option D "Assurance Approach"

This option proposes that abalone are only removed once high population densities of >4000/ha are reached. The proposal is based on the authors' interpretation that the best available science does not support a long-term sustainable harvest at this time, and that even a demonstration fishery has the potential to further disrupt abalone recovery. This option draws on the findings of the modeling effort that concluded that even with a TAC of zero, abalone populations are likely to decline. The actions to be taken under this option include further population monitoring and additional refinement and testing of population models.

a. **Goal & Objectives**: The primary goal of this option is to ensure a long-term sustainable population. The authors propose using risk-averse and precautionary principles to protect Southern California's last remaining

stronghold for red abalone and to safeguard against sudden population fluctuations expected from El Niño events.

b. **Total Allowable Catch (TAC**): This option proposes a TAC of zero as long as population densities are below 4,000 abalone/hectare. When the population density exceeds 4,000/hectare, then this option suggests allowing a TAC that is a fraction of surplus production (to be determined based on available survey data, further modeling and refinements). Thus, this option is not suggesting a no-take approach, but rather a high-density requirement.[20]

c. **Information and Assumptions Used to Identify TAC:** The authors take into account the current modeling conducted by the AAG Technical Panel that predicts a natural decline of the population even with zero take. They note that the current model and existing survey data represent the best available science and no alternate model suggesting a growing population is available. Additional considerations for this option include: estimates that 50% of SMI abalone stock has the bacteria that causes Withering Foot Syndrome; 30–50% mortalities associated with El Niño events; sensitivity in monitoring limited to detecting large (30%) changes in population; precedents for non-recovering collapsed fisheries; and inherently slow population growth.

d. **Phased Implementation and Triggers for Adjusting TAC**: This option proposes that no take be allowed until a population density threshold of 4,000 abalone/hectare is reached (estimated to take 10 – 20 years). If this threshold is achieved, then the fishery could be opened using a TAC to be determined based on available survey data and further modeling. This option also proposes that the fishery be automatically closed during El Niño years as a precaution. In the event the fishery is open, this option proposes that DFG use its discretion to identify the extent and location of areas appropriate for harvesting

e. **Allocation Among Users:** In the event the fishery is opened, any allocations from Options A – C are compatible with this option. No specific allocation is identified.

f. **Management Framework (Funding, Monitoring, Enforcement and Regulatory Issues):** Under this option, DFG would manage the program at its discretion and retain primary oversight over enforcement and monitoring. This option proposes a management approach that emphasizes efforts to combat poaching, particularly in the event a fishery is opened. In the event the fishery is open, this option supports using tags as a viable option.

[20] To clarify, the author suggests that "No take" is defined as a TAC=0 at any density. In contrast, "high-density" includes a requirement that the TAC=0 at density <4000/ha.

Funding: During the period the fishery is closed, this option envisions that the State General Fund or unspecified grants would pay for necessary monitoring and management efforts. In the event the fishery is open, this option supports the use of tags to provide revenue for managing the fishery.

Monitoring, Data Collection, and Modeling: Under this option, modeling and field surveys can be refined and tested until population densities approach 4,000/hectare. This option proposes conducting annual/biannual surveys similar to those carried out in 2006–2008 with the ability to detect changes in the population of 30 – 50%. The authors support the Review Committee's suggestion to try to improve the sensitivity of the monitoring approach. This option proposes the sensitivity be able to detect population changes as small as 10%.

Key regulations needed: The following regulations are proposed:
1) modify the minimum harvest size to 8 inches (203 mm). This minimum harvest size would be the same for both commercial and recreational take and;
2) modify the regulation to require automatic closure mechanisms at population density below 4,000/ha and in years when an El Niño event is forecast.

FUTURE CONSIDERATIONS

As is often the case in managing complex, biologic systems – there is uncertainty. It is hoped that this report highlights the Best Available scientific information and identifies a range of management options for the Commission's consideration.

In developing its options, the AAG members were informed by a modeling analysis, which the AAG members, model developers and reviewers agree needs refinement and supplemental analysis. The supplemental modeling work may help provide a more reliable population estimate over the short term (5 years) and longer term (10+ years) and allow for completion of a risk assessment for a range of fishing options. The AAG members have identified the specific modeling work that is needed (Appendix K).

A major achievement of the AAG's collaborative process is that it has provided a substantial framework to assist the Commission in its decision-making. In responding to the charge laid out by the Commission, the AAG has developed the first, peer-reviewed model estimating the growth of the red abalone population on SMI, identified a range of options for the future management of the abalone fishery, and reached agreement on key recommendations for managing the red abalone resource at SMI. These key agreements are discussed below.

Key Areas of Agreement: Considerations for Managing the Red Abalone Resource at San Miguel Island

The considerations that all members of the AAG and its participating technical experts have agreed upon are foundational to establishing a fishery at SMI. These key agreements include:

1. **Recommendation: Use adaptive management to ensure a sustainable abalone population.** Specific fishery management factors to consider are the use of an adjustable TAC that is based on the most current stock assessment and monitoring surveys; and a strong interest in exploring which fishery indicators, or Biological Reference Points, are most useful for this fishery. The AAG members also recommend increasing the minimum harvest size for red abalone to 203 mm (8 inches).
2. **Recommendation: Improve monitoring sensitivity and data collection to inform adaptive management of the fishery.** Specifically, AAG members suggest that more data collection is needed to help determine the size and structure of the population, as well as provide information on recent recruitment and population increases or decreases. It is also recommended that the precision of the surveys be increased so that they are capable of detecting smaller changes in population density.
3. **Recommendation: Proceed with supplemental modeling work.** The AAG has unanimously agreed that supplemental modeling work is needed to make refinements to the model and project the population over longer time periods and with different levels of risk. This additional modeling work will improve the sensitivity (and efficiency) of the ongoing monitoring effort and will better inform the Commission about the long-term ability for the population to support a fishery.
4. **Recommendation: Guidance needed on moving forward with AAG Process.** AAG members acknowledge that more specificity is needed to implement whichever option(s) the Commission decides to consider or adopt. This will involve direct interactions between DFG and affected constituents.

Such recommendations would apply to any of the management options set forth by the AAG. It is uncertain how or if these proposed management options will be translated and codified into future fisheries management decisions and plans. At present, there are only a select, few examples of state fishery management plans that could serve as a model for the red abalone fishery. In the event the Commission decides to re-open the fishery, these considerations, identified above, could be used as guidelines for creating a fishery plan.

Options for the Future Role of the AAG

At this point in the process, the AAG requests that the Commission consider the management options presented in this Report and, in consultation with DFG, determine

the appropriate course of action for the development of management options for the red abalone population at SMI. The Commission may also wish to consider whether the AAG's work has been sufficiently completed or whether the Commission would like the AAG to continue in some capacity. AAG members have expressed a desire to offer input and provide recommendations to the Commissioners on the potential future role(s) of the AAG.

Below are options for the potential roles of the AAG that the Commission may wish to consider:

- **Establish a Short Term Role:** In the event funds become available and the supplemental modeling is completed, one option is to charge the AAG with reviewing the results of the additional modeling work and amending their recommended management options, as appropriate.

- **Establish an Ongoing Advisory Role:** Another alternative is to have the AAG provide an ongoing, advisory role to DFG and the Commission on management decisions for the red abalone fishery (e.g., help identify appropriate BRPs). The AAG could meet periodically to deliberate and provide direction to the Commission and DFG on monitoring plans, selection of biological reference points, or establishment of a fishery management plan.

- **Bring AAG to a Close:** If there are no further tasks for the AAG, the Commission may consider whether the AAG should be officially brought to a close.

LIST OF KEY TERMS

Key Term	Expanded Meaning
Allee effect	Biological occurrence characterized by a positive correlation between population density and per capita growth rate.
Before-After-Control Impact (BACI)	An experimental design in which designated control and treatment plots are matched based on similarity. An experimental disturbance is introduced and impacts to the study site are compared against the control site.
Biological parameters	A "constant" or numerical description of a biological property of a population (which may be real or imaginary).
Biological Reference Points (BRPs)	A specific type of indicator that specifies a particular biological state of a fishery resource point corresponding to a situation considered as desirable (Target reference point, TRP), or undesirable and requiring immediate action (Limit reference point, LRP, and Threshold reference point, ThRP)
Bootstrap Analysis	Bootstrapping is a statistical methodology used for testing the reliability of a dataset. Computer-generated pseudo replicate datasets are created and used as resampling data. The generated datasets are produced from the original data matrix to create new matrices of the same size as the original.
Catch Per Unit Effort (CPUE)	The quantity of fish caught (in number or weight) with one standard unit of fishing effort; often considered an index of fish biomass (or abundance).
Egg-Per-Recruit Analysis	Analysis of how the magnitude of egg production in a given stock may vary for a given level of instantaneous annual fishing mortality.
El Niño	A periodic change in the atmosphere and ocean of the tropical Pacific region. Changes in pressure difference between Tahiti and Darwin, Australia, brings a warm current of nutrient-poor tropical water to the California Coast, which replaces the cold, nutrient-rich surface water of the Humboldt Current.
Growth model	A mathematical description or representation of the size of a living organism at its various ages; there are many, the most frequently used being the Von Bertalanffy Growth Model.
Haliotis rufescens	Red Abalone
Landings	Weight of what is landed at a landing site; may be different from the catch (which includes the discards).
Minimum Viable Population (MVP)	Minimum density level necessary to protect a population from the risk of collapse in the absence of a fishery.
Population density (number/square meter)	A measurement of population per unit area or unit volume

Population dynamics	The study of changes in the numbers, individual weights, and age composition of individuals in one or several populations, and the biological and environmental processes influencing those changes.
Power Analysis	Analysis of the ability to determine a statistically significant difference between sample and control groups using a standard statistical test.
Recruitment	The number of fish entering any size or size interval; the number of fish added to the exploitable stock, in the fishing area, each year, through a process of growth or migration
Relative abundance (catch/minutes)	The number of organisms of a particular kind as a percentage of the total number of organisms of a given area or community.
Sensitivity Analysis	The process of testing the sensitivity of model results in relation to errors and uncertainties in the input parameters. From the analysis, one can determine the importance of particular parameters to the overall scientific advice.
Settlement (Larval)	Settling of planktonic (free-moving) larvae on any hard substrate
Stock assessment	The process of collecting and analyzing biological and statistical information to determine the changes in the abundance of fishery stocks in response to fishing and other conditions, and, to the extent possible, to predict future trends of stock abundance. Stock assessments are based on resource surveys; knowledge of the habitat requirements, life history, and behavior of the species; the use of environmental indices to determine impacts on stocks; and catch statistics. Stock assessments are used as a basis to assess and specify the present and probable future condition of a fishery.
Stock Recruitment (SR) Relationship	The relationship between the level of parental biomass (e.g., spawning stock size) and subsequent recruitment level. Determination of this relationship is useful to analyze the sustainability of alternative harvesting regimes and the level of fishing beyond which stock collapse is likely.
Withering Syndrome	Disease affecting abalone caused by the bacterium *Candidatus Xenohaliotis californiensis*, which inhibits the production of digestive enzymes. To prevent starvation, the abalone consumes its own body mass, causing its characteristic muscular "foot" to wither and atrophy. Development of the disease in abalone harboring the bacterium has been linked to changes in environmental conditions, such as warmer than normal water temperatures. Thus, abalone are particularly susceptible during El Niño events.

Yield-per-recruit analysis	Analysis of how growth, natural mortality, and fishing interact to determine the best size of animals at which to start fishing them, and the most appropriate level of fishing mortality.

LIST OF FIGURES AND TABLES

APPENDICES

Part I

Appendix A: Fishery Management Options (A-D)

Part II

Appendix B: DFG San Miguel Island Red Abalone Surveys (2006, 2007, 2008)

2006 SMI Red Abalone Survey Final Report
2007 SMI Red Abalone Survey Final Report (*to be available by February 2010*)
2008 SMI Red Abalone Survey Preliminary Summary

Appendix C: Meeting Minutes and Key Outcomes Memos (September 2006 – September 2009)

September 29, 2006 – Meeting Minutes
December 1, 2006 – Meeting Minutes
January 12, 2007 – Meeting Minutes
February 24, 2007 – Key Outcomes Memo
April 6, 2007 – Key Outcomes Memo
June 22, 2007 – Key Outcomes Memo
September 6, 2007 – Key Outcomes Memo
November 29, 2007 – Key Outcomes Memo
December 10, 2008 – Key Outcomes Memo
April 17, 2009 – Key Outcomes Memo
June 8, 2009 – Key Outcomes Memo
September 23, 2009 – Key Outcomes Memo
December 8, 2009 – Key Outcomes Memo

Appendix D: *"Terms of Reference for Technical Panel and Review Committee to Support Development of a Total Allowable Catch (TAC) for Red Abalone at San Miguel Island"*

Appendix E: Technical Panel and Review Committee Members

Appendix F: Modeler's Final Report "*Improving the Stock Assessment of California Red Abalone Haliotis rufescens at San Miguel Island"*

Appendix G: Review Committee's Final Report "*Evaluation of the Red Abalone Stock Assessment By the Review Committee In Support of Deliberations of the Abalone Advisory Group, La Jolla, California 17-18 February 200[9]*

Appendix H: Technical Panel's Final Report "*Developing a Total Allowable Catch framework for Red Abalone at San Miguel Island"*

Appendix I: Modeler's Updates (February – November 2008)

February 28, 2008
April 14, 2008
May 9, 2008
June 30, 2008
July 30, 2008
August 30, 2008
November 30, 2008

Appendix J: Technical Panel Key Outcomes Memos

April 4, 2007
April 18, 2007
February 7, 2008
March 13, 2008
July 7, 2008
August 14, 2008

Appendix K: Scope of Work for Additional Modeling Effort

KEY CITED REFERENCES

Reference 1: *Abalone Recovery Management Plan (ARMP)*: A complete copy of the ARMP can be downloaded at: http://www.dfg.ca.gov/marine/armp/