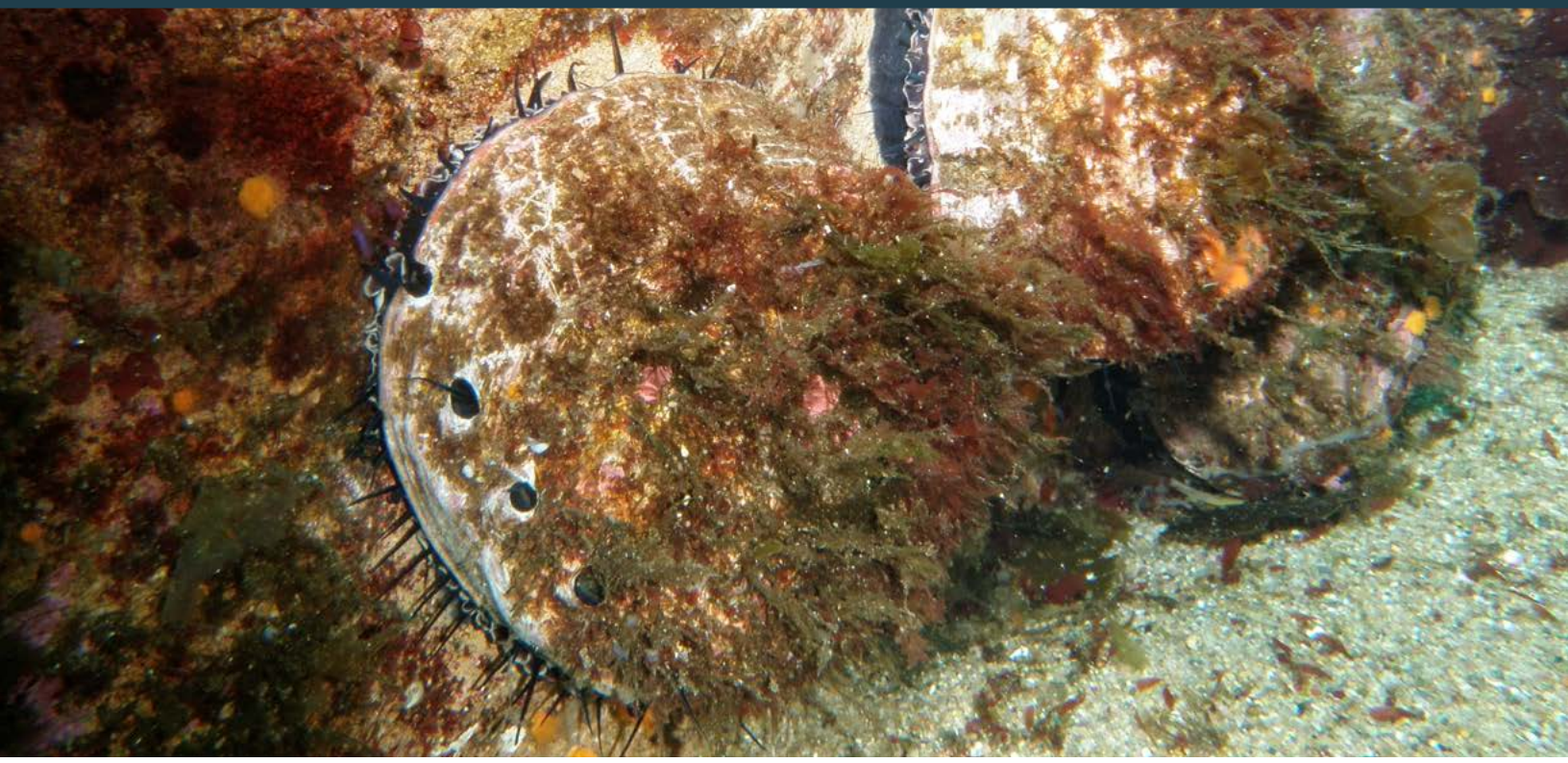
Final Report of the Scientific and Technical Review Panel

Scientific Peer Review of Proposed Recreational Red Abalone Management Strategies



Convened by the California Ocean Science Trust

Supported by the California Ocean Protection Council

October 2018

CALIFORNIA OCEAN SCIENCE TRUST

Review Participants

CALIFORNIA OCEAN SCIENCE TRUST

California Ocean Science Trust is a boundary organization. We work across traditional boundaries, bringing together governments, scientists, and citizens to build trust and understanding in ocean and coastal science. We are an independent non-profit organization established by the California Ocean Resources Stewardship Act (CORSA) of 2000 to support managers and policymakers on the U.S. West Coast with sound science, and empower participation in the decisions that are shaping the future of our oceans. For more information, visit our website at www.oceansciencetrust.org.

Errin Ramanujam, Program Director
errin.ramanujam@oceansciencetrust.org

Jessica Williams, Project Scientist
jessica.williams@oceansciencetrust.org

SCIENTIFIC REVIEW COMMITTEE

Dr. Jason Cope (co-chair)
Research Fish Biologist, Northwest Fisheries Science Center, NOAA Fisheries

Dr. Peter Raimondi (co-chair)
Professor, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Dr. Gavin Fay
Assistant Professor, School for Marine Science and Technology, University of Massachusetts, Dartmouth

Dr. Yan Jiao
Professor, Department of Fish and Wildlife Conservation, Virginia Polytechnic Institute and State University

Dr. Karina Nielsen
Professor, Director of the Estuary and Ocean Science Center, San Francisco State University; Ocean Protection Council Science Advisory Team

Dr. Brian Tissot
Professor, Director of Humboldt Marine and Coastal Science Institute, Humboldt State University

Dr. Will White
Assistant Professor, Department of Fisheries and Wildlife, Oregon State University

Review Participants continued

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

The mission of the California Department of Fish and Wildlife is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

California Department of Fish and Wildlife (CDFW) staff developed a draft FMP including a proposed management strategy that was included within this peer review scope. CDFW staff were engaged throughout the review process. They delivered presentations to the review panel and supplied additional data, information, and feedback to Ocean Science Trust as necessary throughout the review process.

Sonke Mastrup, Program Manager, California Department of Fish and Wildlife, was the primary management contact for this review.

THE NATURE CONSERVANCY- LED STAKEHOLDER TEAM

The mission of The Nature Conservancy is to conserve the lands and waters on which all life depends. Its vision is a world where the diversity of life thrives, and people act to conserve nature for its own sake and its ability to fulfill our needs and enrich our lives.

The Nature Conservancy (TNC) led a collaborative stakeholder team comprised of TNC staff, academic researchers, and recreational divers that developed an alternative management strategy that was included within the review scope. This team was engaged throughout the review process. The team delivered presentations to the review panel and supplied additional data, information, and feedback to Ocean Science Trust as necessary throughout the review process.

Dr. Alexis Jackson, Fisheries Project Director, The Nature Conservancy, was the primary contact for this review.

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Recommended citation: Cope, J., Raimondi, P., Fay, G., Jiao, Y., Nielsen, K., Tissot, B., and White, W. Final report of the scientific and technical review panel: Scientific peer review of proposed recreational red abalone management strategies. California Ocean Science Trust, Oakland, CA. October, 2018.

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Background

In 2005, the Fish and Game Commission (FGC) adopted the Abalone Recovery and Management Plan (ARMP), which governs the management of the recreational red abalone fishery and recovery of southern abalone stocks. The ARMP has two phases of adaptive management: the interim management plan which the fishery is currently managed under, and the long-term management plan. Management changes to the fishery in 2014 marked the beginning of this move to long term management by setting regulations separately for the southern and northern areas of the fishery. The transition to ARMP long-term management provides an opportunity for the California Department of Fish and Wildlife (CDFW) to move management of the recreational red abalone fishery to a fishery management plan (FMP) under the Marine Life Management Act (MLMA).

Thus, it is important for the scientific underpinnings of the draft FMP to undergo external, independent peer review prior to submission to the FGC. This process is one way to provide FGC and stakeholders assurances that FMPs are based upon the best readily available scientific information, as set forth under the MLMA. CDFW drafted an FMP and a proposed management strategy as a part of that plan. The Nature Conservancy (TNC) led a stakeholder proposed management strategy as well. The FGC and CDFW have asked for both the management strategy proposed by CDFW and the stakeholder submitted management strategy, led by TNC, to be included in the peer review. Each of the groups have provided an independently developed management strategy for consideration.

Review Scope

CDFW and FGC's purpose in asking Ocean Science Trust (OST) to conduct a review of the scientific and technical components of both the CDFW and the TNC management strategies to ensure the scientific and technical elements provide a rigorous underpinning for management decisions and regulatory action should they be implemented. Given the unusual circumstance of two proposed management strategies, CDFW sought review input that could illuminate the strengths and weaknesses of each approach to guide next steps. OST is serving as the review coordinating body, and worked with CDFW and TNC to develop a scope of review that focuses on key scientific and technical components of the management strategies where independent scientific assessment would add value.

The central question of this review is:
Are the underlying data and analysis, and application of those in each of the proposed management strategies scientifically sound, reasonable, and appropriate, while also meeting the management goals for the recreational red abalone fishery in northern California as defined by MLMA?

The review will focus on evaluation of the following components of both management strategies:

- Evaluation of the data collection methods that inform management indicators, triggers, and decisions including informing responses to changes in the environment, fishing, or other stressors.
- The scientific rationale for the indicators used and their link to anticipated responses in the abalone population and management decisions.
- The scientific rigour of the proposed quantitative analysis and application of the data and the robustness of the scientific rationale for the proposed management actions it triggers.
- Evaluation of modelling approaches used including model assumptions, analyses, interpretation, and application of the model results to evaluate performance of the harvest control rules against management objectives.
- A general scientific assessment of the proposed methods including application, assumptions, and management implications of uncertainties in the stock status, data streams, and analytical methods within the confines of CDFW capacity and regulatory authority.

For clarity we note that this is not a comprehensive review of the entire FMP. Rather, we are reviewing only the management strategies submitted by TNC and by CDFW. The more detailed reviewer instructions are available online here.

Summary of the Review Process

This review took place from May 2018 - October 2018. Ocean Science Trust implemented a scientific review process that sought to promote objectivity, transparency, candor, efficiency, and scientific rigor. Following a broad solicitation for potential reviewers(coordinated via the Ocean Protection Council Science Advisory Team), a multidisciplinary, seven-member review panel was assembled, representing expertise in fisheries science and management, abalone ecology, and modeling, among other subjects. OST facilitated constructive interactions between reviewers and both author teams through a series of remote meetings, where CDFW and the TNC-led stakeholder teams presented an overview of the science and technical elements under review, and were available to answer reviewers' questions. In addition, OST convened reviewers independently to allow the review panel to candidly discuss the review materials and conduct their assessment. Ocean Science Trust worked with the review panel to assemble and synthesize their written and verbal responses to guiding questions, as well as discussion from remote meetings into this final report. This report is publicly available on the Ocean Science Trust website.

Additionally, OST led a community engagement webinar to answer questions about the peer review process and scope of the peer review. A summary of that meeting and all questions submitted are included in Appendix A.

Project Materials Under Review (both available on the Ocean Science Trust website)

1. CDFW submitted management strategy
2. TNC-led stakeholder submitted management strategy

Review Recommendations

Summary of Main Findings

Both teams submitted very different strategies that represent a tremendous amount of work to find management solutions for a very complicated recreational red abalone fishery where life history traits and uncertain environmental conditions play an active role. Given this, California Department of Fish and Wildlife (CDFW) and the Fish and Game Commission (FGC) have requested, and we recommend, a fisheries management plan (FMP) that can manage under any future environmental scenario and respond to changes in the red abalone population using the best available science. What we discovered during the course of this review was an opportunity to look at the data and strategies holistically to:

1. make recommendations to bolster the scientific rigor of each strategy, and
2. find areas where synergies between the two plans can come together and increase the chances of successfully tracking changes in this population in support of scientifically sound management decisions.

This review cannot provide advice on setting or deciding upon risk thresholds, management measures to accommodate different levels of catch, or determine appropriateness of opening a fishery with low levels of catch. While elements of these types of decisions could be supported by existing or new scientific analyses, they were outside the scope and timeframe of this particular review. We have reviewed the scientific elements of all materials under review and made recommendations where further work is needed. Ultimately, we wanted to know under what circumstances a particular indicator or suite of indicators might capture or miss a rapid or slow change in the red abalone population. This is the lens through which we evaluated the materials under review. To put the rest of our review in context, we have summarized our findings about each strategy under review here. We address them simultaneously throughout the rest of the report.

Summary of Findings of Each Management Strategy

CDFW submitted management strategy

This management strategy emphasized the direct measure of biological and ecological conditions of red abalone for both setting catch in an open fishery as well as decisions about when to close and re-open the fishery. It has taken the traditional density approach and combined it with new indicators that are on the forefront of monitoring and predicting changes in the red abalone population (body condition, gonad health, kelp cover, sea surface temperature, etc.; Table 1). These measures make intuitive sense, but can be costly and logistically difficult to obtain. We believe that some subset of these indicators can likely provide the biological component needed to manage this fishery. However, without simulation testing (e.g., in these cases, computer-simulated population dynamics used to test a variety of questions regarding measuring and managing populations) of these indicators and better defined reference points, we cannot recommend which combination of indicators and reference points are most robust to uncertainty in red abalone status. Additionally, we know abalone density to be a preferable way to measure the population status. We also know it to be very labor intensive to collect enough data to make the metric informative at the scale at which it needs to be for making site or county level decisions.

Simulation testing would better establish how current or proposed density monitoring can be used as an informative metric for management decisions, as well as give insight into better ways to formalize the use of metric uncertainty (i.e. high variance) into decision making. Additionally, the density metric currently requires three years to get a complete set of data for all sites, thus increasing the chance that density could change in off-sampled years/sites, limiting management responsiveness. We also believe that through simulation testing, CDFW can better understand how to use the new environmental and productivity indicators and find ways for them to better support more robust decision making. We also note that the type of evaluation done in the current strategy is insufficient for performance testing of indicators. Lastly, we want to highlight that we consider the biology of this species to be highly important to understanding the population of red abalone. We believe the other environmental and productivity indicators (especially kelp cover, gonad health, and body condition) need to be further explored, tested and refined. We think that this testing and refinement will lead to more meaningful indicators, that can be collected more quickly, and inform management decisions on a more timely basis, increasing scientific robustness.

TNC-led stakeholder submitted strategy

This management strategy is a more traditional fisheries management approach for managing the fishery when it is open. It applies two relatively data-limited approaches,--length based spawning potential ratio (LB-SPR) and catch-MSY-- as indicators used to adjust catch. The approach was tested using simulation testing with an operating model approximating red abalone biology and population dynamics. This management strategy has the benefit of relying on tested and refined indicators used in other fisheries that have benefited from simulation testing. It also has the ability to track the general population dynamics with relatively little data, but with one major caveat: neither indicators, nor the operating model, incorporate the needed specificity in low density dynamics of red abalone. Our review found that the model does not explicitly incorporate certain low (e.g. Allee effect) or variable (e.g. body condition) population situations, making it difficult to determine how well this multi-indicator approach will perform at low densities, when disease alters population conditions, or if mortality events impact all lengths equally. There are currently no biological modifications in the interpretation of lengths to detect poor conditioned individuals.

Pairing this multi-indicator approach with other biological indicators that detect metrics such as low density dynamics and/or body condition issues could significantly improve performance. This will likely lead to different additional catch-setting options to be tested, as well as modifications to the operating model to incorporate more specific low population dynamics conditions so as to better measure option performance. There is also the need to consider what methods and reference points would be used to reopen an already closed fishery.

Summary of Peer Review Recommendations

As written, all strategies contain a high level of uncertainty. All individual indicators and the ways in which they operate under each management strategy need revision in order to reduce uncertainty. Given unpredictable data streams, changing ocean conditions, and unpredictable changes in the ecosystem where red abalone have traditionally thrived, it is advantageous that any plan leverages a suite of available indicators to present the clearest picture of the population status.

We want to emphasize that even though there were two approaches applied, they both come to the same conclusion with respect to the current status of the population. These common findings are ultimately how and why we think they can be integrated in support of better scientific grounding for management of this fishery. We found that both proposals could be strengthened by each other to ensure accurate and timely tracking of the red abalone population, subject to cost constraints. We have reviewed each indicator in and of itself and then made recommendations about how they could combine with other indicators to maximize synergy in this data-limited system.

Recommendation 1: These two management strategies should be integrated to reduce uncertainty and take advantage of the best available science.

We find that while each plan could potentially be altered to operate independently of the other, high levels of uncertainty would remain regarding specific thresholds or triggers for opening or closing the fishery. This level of uncertainty means it is possible the models could result in decisions to fish the population when it should be closed or keeping the fishery closed when it could be open. Luckily, we found that elements of each plan, data streams provided, and thinking from both teams could be combined to form a potentially more cohesive plan and potentially greatly reduce the risk of overfishing and increase management performance. Throughout this report we have made several recommendations to make individual indicators more robust as well as highlight potential areas for integration. While no one can predict the future and there is no risk-free plan, careful consideration and integration of these plans, as well as specifying risk tolerance, can create a scientifically robust plan on which to make sound management decisions.

Recommendation 2: The way to integrate indicators, data streams, and analysis should be tested and analyzed using simulation testing from a formal operating model specified to capture low-density population dynamics specific to red abalone.

For this report we present examples of how to address these needed changes. We did not make specific recommendations about which suite of indicators would be appropriate and their respective reference points. This recommendation will require simulation testing on all indicators which was outside the scope and timeline for this review (see Table 1 for a full set of indicators under review). Simulation testing can help to illuminate the right combination of indicators that may reduce uncertainty below acceptable thresholds by balancing a combination of different data collection methods with various associated cost, risk, and statistical power (see Figure 1). This simulation testing, or modeling analysis, should be stress tested and analysed using computer simulations that are specified to capture low-density population dynamics specific to red abalone.

For this report we have summarized our review into two sections: 1) management strategies for re-opening, and 2) managing under an open fishery. However, these topics are highly interrelated and many recommendations from both sections apply to the other. For example, we talk about using environmental indicators, density, and LB-SPR in the re-opening section. However, we would not recommend applying any of these indicators or plans without implementing the two recommendations above.

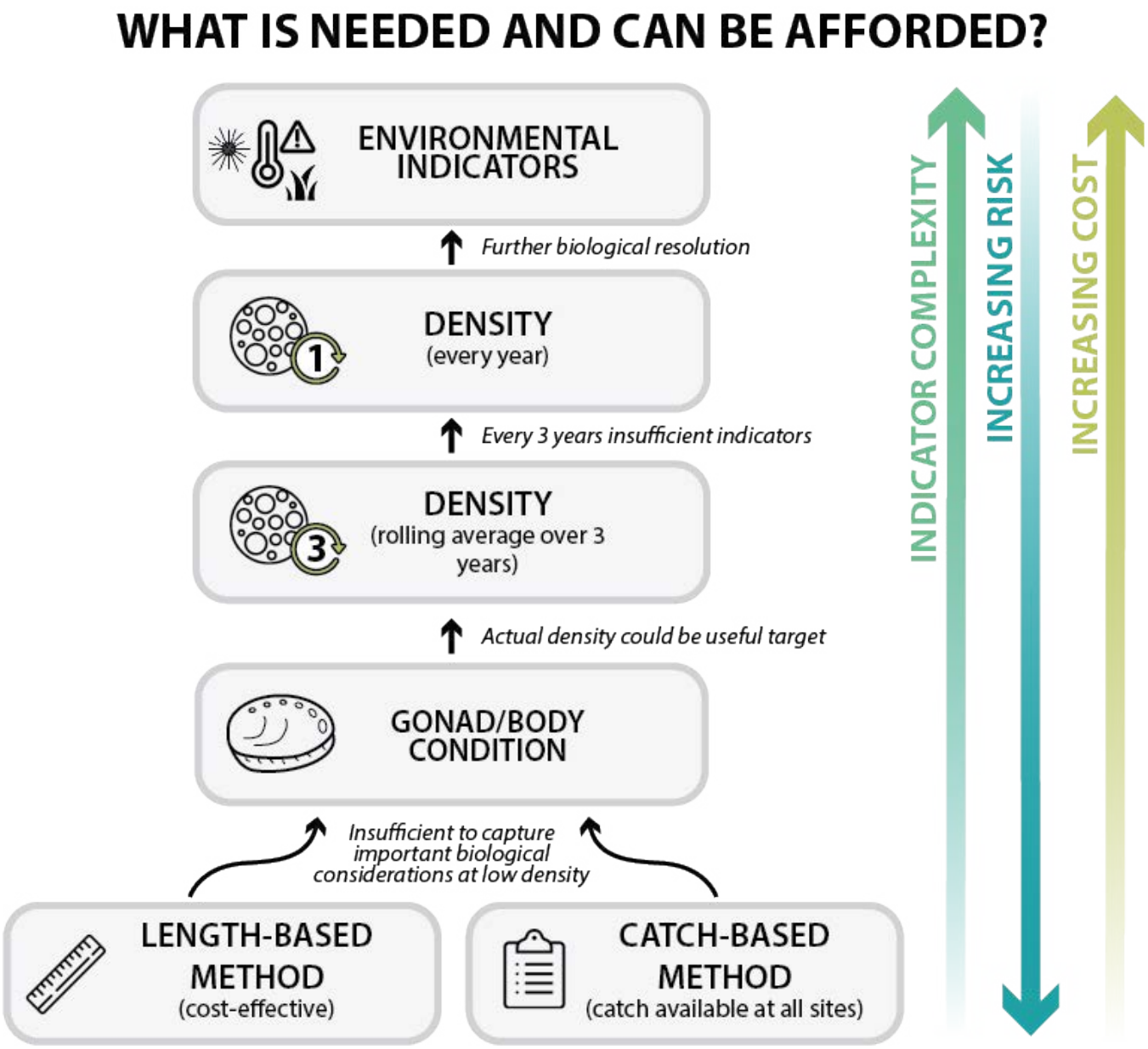

Figure 1. Theoretical flow chart indicating some of the ways in which different indicators can be visualized along the differing scales of complexity, risk, and cost. We selected several of the provided indicators to show the ways in which they compare on these scales, but did not include all provided indicators (see Table 1). Complexity refers to increasing the number indicators that need to be monitored and reconciled with each other.

Table 1. List of the indicators, associated reference points, rationale for reference point chosen for each management plan. In some cases we indicate that there was no basis provided for the reference point. This simply means a written explanation was not provided in the written report. It does not mean that there is none, or that the indicator is not relevant to the fishery.

Plan Source	Management Phase	Indicator	Reference Point	Basis
CDFW	***Catch-setting***	Target catch	+/- 25% (no change to catch if within this range)	Wide enough to be insensitive to minor fluctuations (p. 5-12)
		Baseline catch	Catch average from 2002-2006	No large scale impacts to survival and fishery was stable
		Baseline density	0.63/m^2	Average value during baseline years
		Density target	0.5/m^2	Shift in fishery catch dynamics happens below this value (p 5-15)
		Average density limit	0.3/m^2	Above 0.2/m^2 (the minimum viable population density set p. 5-16), limit based on site density to catch (App. B, Fig. 1)
		Site density limit	0.25/m^2	Above 0.2/m^2 (the minimum viable population density set p. 5-16), limit based on site density to catch (App. B, Fig. 1)
		Regional density of deep water abalone	low: 0.2/m^2; high: 0.4/m^2	Not specified in chapter 5
		Gonad index	<100 for ≥60 abalone that are ≥7”	Not specified in chapter 5
		Body condition	≥15% with shrinkage score >0 (sample size of ≥500 abalone)	Not specified in chapter 5
		Ocean temperature	>15°C at 30 ft. in Mendocino county on any day in the previous calendar year	Not specified in chapter 5
		Kelp abundance	≤30% historic max coverage in either Mendocino or Sonoma county	Not specified in chapter 5
		Sea urchin density	Combined density of red and purple are ≥5 urchins/m^2 at any of the index sites	Not specified in chapter 5
	Re-opening	Site density reopening threshold	>0.4/m^2	Set to be 60% above the site closure trigger to buffer against re-closure
		Size frequency	≥40% legal-sized; ≥30% sublegal (with a sample size of ≥500 abalone)	Similar to baseline (2003-2007) conditions
		Regional density of deep water abalone	>0.2/m^2	Not specified in chapter 5
		Regional density reopening threshold	>0.45/m^2	Not specified in chapter 5
		Ocean temperature	≥15°C at 30 ft. in Mendocino county on any day in the previous calendar year	Not specified in chapter 5
		Kelp abundance	≤30% historic max coverage in either Mendocino or Sonoma county	Not specified in chapter 5
		Sea urchin density	Combined density of red and purple are ≥5 urchins/m^2 at any of the index sites	Not specified in chapter 5
TNC- led	***Catch-setting***	LB-SPR	SPR/SPR_{MSY}; high (>1.1); stable (>0.9 & <1.1); low (>0.5 & <0.9); extremely low (<0.5)	Not specified in report
		Catch-MSY	U/U_{MSY}; U/U_{MSY} levels: high (>1); low (<0.75), stable (>0.75 & <1)	U_{MSY} = r/2 and U is catch in final year/B_0; Levels not specified

1. Managing Under a Closed Fishery

In general, we found that the field sampling may provide some information on stock status, but does not alone give the robust tools needed to make management decisions about re-opening. At the beginning of this review, we received information from both teams with a variety of data streams and indicators which we think will be useful to making a robust plan for consideration of re-opening the red abalone fishery.

Because of the red abalone population decline and the current fishery closure, we believe it is important to first address the current situation of the fishery. The FGC closed the fishery due to evidence of a substantial decline in the population on December 7, 2017. Due to this shift in the population we initially focused on reviewing the data and the plan for re-opening a closed fishery, where provided, as well as all other data and indicators that could be used to inform managing under this closed fishery scenario. CDFW included a re-opening section in their plan providing a basis to make preliminary recommendations. We understand that this change in the abalone population is new and commend both teams for adapting their thinking and plans, where they were able, with available time and resources, to include this new information. Given the current status of the population, we think ensuring the scientific underpinnings of how to reopen the fishery is critical and timely.

1.1 Key recommendations

Recommendation 3: All indicators chosen must be clearly defined, and ideally, all candidate reference points for any indicator should be tested using simulation testing in a closed loop analysis.

Indicators from both plans, regardless of whether they appear in a re-opening context, should be evaluated for their usefulness in making management decisions related to re-opening. We recommend that any threshold or indicator chosen as part of the re-opening plan needs to be fully defined. This includes:

- clearly stating the values for, and rationales for, indicator thresholds (which have been set and tested through formal simulation operating models)
- indicating the baseline for comparison of indicator status, whether it be a reference year(s), statistical summary, or data where applicable
- describing and demonstrating threshold detection analysis, including variance, power, etc.
- plans for how and when the data will be collected in support of measuring these thresholds and, where appropriate, back-up plans for when data sets are not available

Selecting reference points based on expert opinion or judgement may also be a viable route when other sources of evidence for setting reference points are not readily available. However, the scientific rationale for the specific reference points chosen needs to be well articulated and supported by multiple experts. Expert judgement may result in greater uncertainty regarding specific reference points. In some cases, setting an arbitrary number may be worse than not including the indicator at all or using a different framework for decision making. In this case, our understanding is that all of the indicators presented are sufficiently well-developed to have the information needed for at least basic testing using a formal operating model of the system, which can include evaluation of implications of data availability. These simulation models can help test and refine the relationship between these indicators and the red abalone population. Thus there should be no need to include indicators that rely on expert judgement alone.

We explore two indicators to demonstrate how to implement the above and the types of questions that should be asked.

- *Example 1- Kelp Cover*: The reference point for kelp cover under re-opening is 30% cover.
    - o How was this reference point chosen? Was it tested using simulation in a formal operating model? Answering these questions will aid in a more clear selection of:
        - What the current kelp cover is being compared to (e.g. an average of all past years? The previous year? The whole area covering the fishery? Areas inside and outside of MPAs? Area by county? By site?)?
        - What types of data are acceptable for assessing this metric once established (e.g. kelp bed flyovers, dive surveys, visual assessments from land)?
        - What should be done when these data are unavailable?

- *Example 2- LB-SPR*: This indicator was not discussed as part of the re-opening management strategy, however it could be included by setting a threshold level that the indicator would need to achieve (presumably from fishery independent sampling) for setting catch under re-opening. If LB-SPR is evaluated in a formal simulation model, and if selected, managers should assess and clearly address:
    - o How was this reference point chosen? Was it tested using simulation in a formal operating model?
    - o How does the threshold value interact with the precision of reference point estimation in terms of assessing risk of re-opening, to both the stock and yield from the fishery?
    - o What does the status of additional (combination of) indicators need to be for LB-SPR to be used as a re-opening indicator?
    - o What should be done when length data are unavailable?

Recommendation 4: A multi-indicator approach, with little to no tiering, where not all indicators need to be met (i.e. not adopting a "one out, all out" approach), may be more flexible and informative given the uncertainty of changing ocean conditions and the response of red abalone to these changes. The structure of this approach and choice about whether to make it sequential (single indicators triggering another single indicator and so on), tiered (groups of indicators that trigger next tiered group of indicators and so on), or simultaneous (all indicators assessed simultaneously) can and should be tested using a formal operating model, thus building in a structure that is not subjective.

Given the uncertainty of data streams, changing ocean conditions, and the way different species and ecosystem features may interact with red abalone populations now and into the future, we recommend a re-opening plan that allows for flexibility and the possibility that red abalone may adapt to some of the "negative" indicators in the future. For example, if moving inshore becomes a way for abalone to find enough food, but kelp cover remains low, would this alone be a reason to keep the fishery closed if all other indicators are positive? Thinking through these types of emergent patterns along with their consequences is essential. We recommend using scenarios such as this to make decisions about how many of the indicators need to be met in order to move to the next tier of data collection or to open the fishery (e.g., the traffic light approach; Caddy 2002). A decision tree framework like the one already proposed could be adapted and a useful way of outlining this process.

Testing these decision points in simulation testing in a formal operating model is one way to provide rationale for these choices. Feasible structures for the sequence or tier structure can be assessed through participatory processes with experts, so as to ensure that the number of simulated possibilities tested is kept to a manageable number. It is impossible to anticipate the full range of possible future scenarios, but simulation testing offers a path to identify strategies that are unlikely to work, and ones that may be robust. Coupled with a detailed rationale for decision points associated with adaptive measures, this ensures a transparent way of continuing engagement. An adaptive FMP would allow for ongoing scientific engagement into the future as new, unanticipated scenarios come into play.

2. Evaluation of Management Strategies for Open Fisheries

As mentioned, FGC requested from CDFW an FMP that can manage under any future scenario. Once a fishery has been deemed ready for re-opening, there is a need to have a plan with a strong scientific backing to ensure management decisions can respond quickly to changes in the population, especially given changing ocean conditions and the uncertainty created by them. Ideally, as recommended above, the plans for re-opening and managing after re-opening should mirror each other. This will streamline data collection, analysis, and management decisions.

This review was scoped to look at the scientific underpinnings of the elements provided in the management strategies and other materials provided (all materials available on the Ocean Science Trust website). While our review can illuminate the risk this may pose in terms of outcomes under different scenarios it cannot and it would not be appropriate for us to make decisions about the appropriate level of risk managers and fishing community members are willing to assume under any given management strategy. We attempted to provide insight about the inherent risk of missing a population change under each management strategy and make recommendations to improve performance should managers determine that the associated risk needs to be reduced. However, it was outside the scope of this review to determine management options for setting risk, choosing management measures to accommodate different levels of catch, or to determine the appropriateness of opening a fishery with low or high levels of catch. Should this be of interest in the future, science can help managers and community members understand the risk associated with each of these and potential outcomes for the red abalone population, but it cannot make these value based judgements.

We assessed each indicator individually and holistically to determine how they might perform under different scenarios. Ultimately, we wanted to know under what circumstances a particular indicator or suite of indicators might miss a rapid or slow change in the red abalone population. This is the lens through which we evaluated the materials under review. We have evaluated the scientific elements of both and, when able, provided recommendations for strengthening the different components and the overall management strategies of both. It should be noted that it is outside the scope of this review to provide the best way to fix any weaknesses we may have identified.

We have concerns that even after incorporating the recommendations we provided, these plans individually could still lead to fishing on a population that is not sustainable or result in keeping the fishery closed long after populations are able to sustain some fishing. Changing ocean conditions, changing dynamics of how red abalone interact with their environment, specifics of data collection and analysis, as well as the inherent attributes of these indicators, are among the factors that limit predictability in management outcomes here, and are not unique to this fishery.

Reviewing these two different approaches is actually fortuitous for red abalone management as it allowed us to see the relative strengths and weakness of each approach more clearly. As a result, our review finds and recommends that a more holistic approach be taken for the red abalone FMP. When looking at all components of the management strategies side by side, they provided a much more robust suite of indicators. Not only that, they seem to connect to each other in unforeseen ways, filling gaps and uncertainties in the other and vice versa. It is outside the scope of our review to provide a new integrated plan. However, we recommended that these plans be evaluated to determine the appropriate ways to integrate these indicators to come up with a comprehensive management strategy. By doing this work, and then evaluating it through a formal simulation operating model, the outcome will be a plan that is scientifically robust, uses a multi-indicator approach, and hopefully reduces the risk of overfishing.

Each of these plans represent core components of what should be included in a scientifically robust management strategy for an open fishery. We see opportunity for them to work together holistically. In isolation, both plans under review have uncertainty that needs to be addressed in order to improve the estimates of population status. Integration of these plans, utilizing simulation testing, is recommended.

Any FMP should use a Management Strategy Evaluation as a matter of best practices, including stakeholder engagement. The target catch evaluation is useful for understanding past decisions and outcomes of alternative decisions given previous resource state, but is not a replacement for a formal Management Strategy Evaluation or other formal simulation testing. The current Management Strategy Evaluation would benefit from changes to increase its performance for the plan for which it was developed. For example, M used in the simulation system is based on an estimate from Leaf et al. (2007), and seems inconsistent with the one used in LB-SPR. There would likely need to be changes to the model to incorporate the recommendations in this report. For example, multiple indicators are suggested to be incorporated in the simulation model and management plan tested with the Management Strategy Evaluation framework. However, it is still an good basis for testing and refining any one or a suite of changes made to the management strategies under review for incorporation into the FMP.

In summary:

- Capitalize on the strengths of the strategies already provided by integrating elements of both into a potentially more robust plan.
- In order to combat the possible loss of data streams, a multi-indicator approach that makes allowances for and explicitly states changes that need to be made when data streams become unavailable for any given indicator is preferred.
- The management plan should explore how the multiple indicators will interact. Does every indicator need to meet thresholds? Is a subset of the indicators meeting reference points enough to make management decisions (e.g. what happens when kelp cover and red abalone density are past the positive threshold, but urchin densities remain high?)? Simulation testing can be used to test and describe this robustness.
- The management plan should explore the order of operations for any suite of indicators and how they work together.

2.1 Key recommendations

Recommendation 5: Setting reference points for every indicator is critical. (See also recommendation 3)

All reference points need to be more explicitly defined including information on what they are and how reference points were set (Table 1). There needs to be more justification and better articulation on their contribution to the management plan, how and why they were selected, and their role in making specific management decisions, including fine and coarse tuning. Our strong recommendation is to test these indicators (as described in the above recommendations) in a simulation modeling scenario wherein this uncertainty can be explored and proper thresholds that formalize the way in which you deal with uncertainty can be explored (see also recommendations 8, 9).

We have provided the following examples as guidance for how to implement this recommendation for any indicator chosen to include in the management strategy:

- *Example 1- LB-SPR*: This indicator is used to reflect the exploitation intensity through observed length frequency. However, in cases such as unexpected high mortality across ages and sizes, small sample size, poor gonad or body conditions, and population aggregation etc., this indicator may not be able to detect the correct signal of the population status and exploitation over short time scales, likely greater than one year but less than three-four years. The LB-SPR indicator may make sense at higher population sizes not affected by low-density population dynamics (e.g., Allee effects), but at reduced population sizes, this indicator a) needs to be tested for robustness to these Allee effects and b) would benefit from additional biological indicator(s) that better captures red abalone population dynamics at low population sizes or in instances where lengths are less informative of mature biomass (e.g. poor gonad or body condition).

One solution to test would be extending LB-SPR by using length frequency across multiple years to validate the population results behind the data instead of only using yearly observations separately. LB-SPR may also be used to simulate a "healthy" length frequency target and threshold (e.g., P(L>Lsublegal)) under alternative conditions so that length distribution can be used as one of the indicators in opening or managing the fishery, which is how it is currently being used in the proposed strategy.

- *Example 2- Kelp Cover*: As it stands there is very little certainty about the thresholds that have been set for this indicator as well as the other productivity and environmental indicators or the ways in which they directly correlate to the red abalone population itself (see Table 1). In theory, kelp cover should indicate the abundance of a favored food resource for red abalone, presumably the availability of drift kelp. The dominant kelp in northern California is Nereocystis luetkeana (bull kelp), an annual species, that can be a responsive indicator of annual ocean conditions impacting kelp populations (waves, warm waters, nutrients, etc.). However, the relationship between kelp cover of Nereocystis, drift algal abundance, and red abalone condition has not been established (nor has the form of the relationship). Thus the basis for any particular threshold in kelp cover is unclear and has a high degree of uncertainty associated with it, given the available evidence.

  As a result, it should not be used directly to trigger management decisions. However, given there is a known trophic link between these two species, and between ocean conditions and kelp cover, it may be beneficial to use a conservative kelp cover threshold to trigger inclusion of other indicators (e.g., gonad condition), as is the case in the CDFW management strategy currently. Indicators such as this should be treated as uncertain and therefore there should be flexibility and adaptive capacity should be built into the system to change these indicators as more information becomes available or to bypass them entirely should the red abalone population show other signs of recovery.

Recommendation 6: All indicators should be evaluated alongside each other in formal simulation modeling to set reference points and to test and determine the appropriate suite of indicators.

Both management strategies presented approaches that need to be bolstered in order to reduce uncertainty. We recommend taking a holistic approach and assessing all indicators alongside each other to find the right subset of indicators to reduce uncertainty using a formal operating model, such as a Management Strategy Evaluation. One management strategy under review relied heavily on density while the other under review relied on LB-SPR and exploitation rate estimates. Other indicators were included (e.g. body condition, gonad health, etc.), but we focus on the two prominent ones.

Below we demonstrate the concerns with the two indicators and then show the ways in which these concerns could be alleviated through integration.

Prominent indicators as currently used:

- *Density (10 sites)*: Length frequency density data are the gold standard for tracking invertebrate populations. The issue is that these data can be highly variable and very time consuming or costly to gather at the level needed to be scientifically meaningful for fisheries management. For this density indicator, as currently implemented, the length of time required to revisit each site (three years) as well as the low levels in the power analysis at anything other than the whole fishery (which takes three years to complete) makes it inadequate for informing annual management decisions, especially when environmental conditions change rapidly. Additionally, this indicator for red abalone varies substantially among local sites surveyed. Gaps in data between years for different sites confounds estimates of change among years with changes in site representation in the data set. As a result, changes in apparent population status between adjacent years (or lack of change) might be incorrect and cause the fishery to either close or re-open when not warranted.

- *LB-SPR (15 sites)*: LB-SPR is a traditional fisheries management tool and uses an assumption that changes in the population are related to mortality events, including fishing. Here in California we know that changes in the population can be due to either catch, environmental conditions, or other unidentified mortality sources

such as poaching. Given the life history traits of red abalone, it will not be sensitive enough to recognize changes in the population under changing ocean conditions, when body conditions change and especially when population size is low, and low-density population dynamics prevail. Under plausible scenarios, this indicator could take several years to indicate a change in the population. Pairing this indicator with catch-MSY alone is not sufficient to make up for this potential to allow higher levels of fishing on a population that is in decline. We also have several concerns that the Management Strategy Evaluation that evaluated LB-SPR and catch-MSY did not show any sensitivity to changes in harvest or other events that mimic those such as harmful algal blooms, disease, starvation, etc. We suspect that this is due to the lack of biological indicators and speaks to the need for an analysis of whether or not the LB-SPR metic is able to detect changes in the population at very low densities.

Investigating the right suite of indicators for an integrated management strategy

This should be done through a series of evaluations using a formal operating model such as a Management Strategy Evaluation on all indicators provided in both strategies. While it is outside the scope of this review to find or select all options, here are several for consideration and testing. This should be done for all indicators in Table 1 to determine the right suite of indicators needed to meet management goals:

- We know that density and LB-SPR can be correlated with each other. One concern under LB-SPR is that when density declines to low levels, that LB-SPR is masking Allee effects. It could also be be masking other indices of populations such as body condition, etc that may or may not be linked to density. Density can be used to set a LB-SPR threshold above which we know there is very little chance of Allee effects or other low density effects that are undesirable. Therefore, LB-SPR threshold could be set high enough where we have strong scientific confidence that it is well above the level of density where it stops being able to track changes in the population.
- LB-SPR may also be masking population changes (such as the current one) where the population is in decline. There are two separate issues: 1) a discrete mortality event that affects all size classes would not cause an immediate change in LB-SPR, but would show up in density estimates; 2) an overall increase in mortality due to poor conditions will change LB-SPR (even if it is affecting all size classes equally) but the change may be slow enough to have a lag in detection.
- Density estimates have other deficiencies (see above). Density needs to be paired with indicators that can be collected on an annual basis and with greater statistical power. By pairing biological indicators such as density with body condition and/or gonad size, along with LB-SPR the ability to track changes in the population and detect them earlier is increased. Simulation modeling can and should test how and if these two indicators, LB-SPR and density, track alongside each other. It also relieves the need for density information to be collected at every site on a yearly basis in order to be meaningful (note: we did not test that sampling all 10 sites on a yearly basis would allow for the power needed to make management decisions on a yearly basis at any scale finer than fishery-wide).
- All of these changes should be tested in formal closed loop simulation testing that can help set the specific triggers related to density, LB-SPR, body condition, etc.

Recommendation 7: All indicators need to transparently indicate, and then formalize the way in which they deal with uncertainty.

Each of the indicators (Table 1) presented in both of these management strategies are not measured without error. However, the levels of uncertainty vary across these indicators. This uncertainty needs to be more transparently described in how it is calculated and formally treated in the management procedures. This formalized treatment currently seems to ignore all uncertainty by using a measure of central tendency, avoiding the risk associated with uncertain values. Whether directly measured (e.g., abundance) or estimated (e.g., LB-SPR), each indicator should not assume the median value is the best choice for management use. Any indicator with high amounts of uncertainty that uses the median could wrongfully declare a fishery open or closed, or increase or reduce catches when the opposite should have been done.

Uncertainty can be dealt with in many ways. One common approach is to define a quantile that is below the median value (i.e., 0.5; Ralston et al. 2009). This approach could be considered for any of the indicators in Table 1, and the exact value should be tested for robustness in a simulation testing framework. Other scientific methods for dealing with uncertainty were outlined in the red abalone density estimate peer review (SAC 2014). However it is done, all indicators should have some consideration on how uncertainty is treated and the proposed treatment performance tested under different scenarios.

Recommendation 8: The science underlying setting catch levels needs to be re-evaluated and re-configured.

Recommendation 8.1 Consider changing the order of operations for indicators when setting catch.

We recommend that both management strategies, as well as any integrated options, reconsider the order in which indicators are used and the ways in which they connect. Typically, indicators with robust reference points are used to set catch limits. This is important because they are clearly defined and uncertainty has been quantified. Additionally, perceptions of resource status and confidence in advice outcomes can sometimes be biased by the order in which operations are done with respect to expected baseline or reference values. Although several orderings of operations may lead to the same outcome in terms of advice, some may be more preferred by relevant stakeholders. Several examples of this include:

- Reversing the order in CDFW approach. Usually catch is set by first using indicators that have robust biological reference points that adjust catch. However, the CDFW approach starts with catch and then uses different indicators to adjust it. This is problematic because the indicators of current status are not the ones being used to determine exploitation levels.
- LB-SPR can provide a relative measure of stock status (e.g., transient LB-SPR). Relative stock status is an input into the catch-MSY method. It is suggested that the estimate of LB-SPR be considered as a prior for the stock status input of the catch-MSY method so as to make the catch estimation more consistent with the length information on stock status. This would avoid having to define decision rules for either LB-SPR or exploitation status, and would directly use the catch-MSY estimates of catch to set the sustainable catch limits. Some thought on the appropriate measure of uncertainty (likely underestimated by LB-SPR) for the prior would still be needed, and could be explored through sensitivity analyses in LB-SPR.
- By implementing recommendations 1 and 3 (above), alongside a formal Management Strategy Evaluation (recommendation number 11 below) on all indicators and their reference points, there can be a more scientifically robust way for determining which indicators work best together and which ones are redundant for providing catch advice.

Recommendation 8.2 The mechanisms for setting catch need to be re-evaluated and perhaps merged.

Both plans presented different mechanisms for setting catch. And again we find that neither is complete in and of itself. Using a baseline catch, as used by CDFW to set current day catch where conditions and population levels are completely different, is likely not going to be useful going into the future. The population may be continuously over or under fished given the adjusted percentage of changes in catch, especially when the uncertainty of the indicators are of high levels. The baseline catch approach is also difficult to use when a population is largely depleted, or when a population is recovering. Under the TNC-led management strategy, catch is set using a combination of LB-SPR and catch-MSY ratcheting down over time. This is problematic because of both the potential delays in tracking declines in the populations and the lack of having clearly demonstrating that this ratcheting down of the catch will not result in fishing on an overfished or decimated population (i.e. it needs to better demonstrate why there is not a need for a threshold or reference point at which the fishery closes). One option for integration might be that by jointly using density as a reference point together with LB-SPR, to assess stock status, and using catch-MSY for setting catch.

Recommendation 9: Align the re-opening plan to match how the fishery is managed under other management scenarios to streamline data collection, analysis, and the decisions that follow.

This last recommendation should be addressed as time and resources allow. Streamlining the re-opening and the management after re-opening can often be simpler, more transparent, cost effective, and in alignment with fisheries management best practices.

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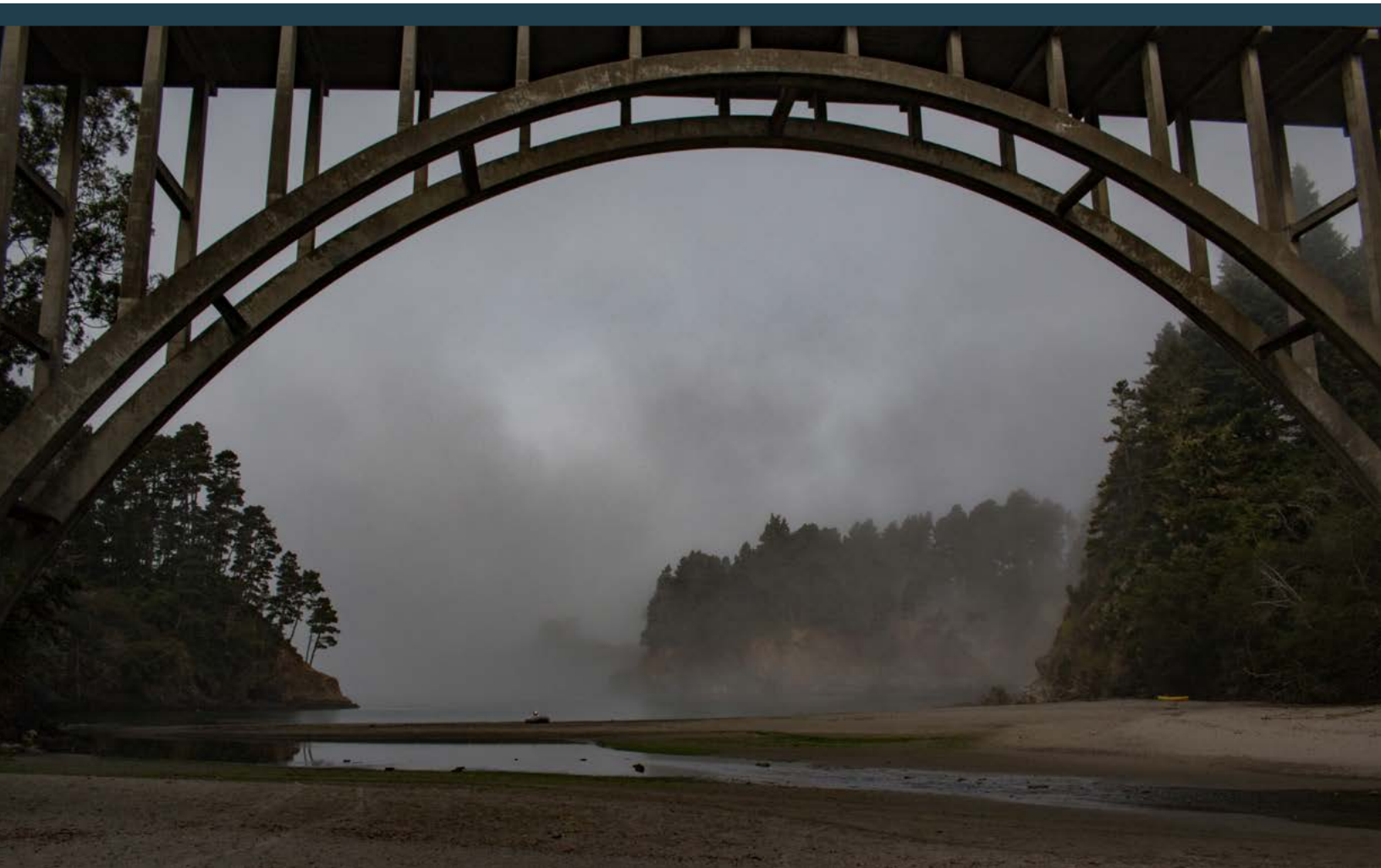
California Ocean Science Trust

1111 Broadway, Suite 300
Oakland, California 94607
oceansciencetrust.org



Public Webinar to Discuss the Red Abalone Community's Science-based and Peer Review Process Related Questions

Summary of Key Themes
Recreational Red Abalone Fishery Peer Review

August 20, 2018 | Webinar Recording

Overview

California Ocean Science Trust (OST), as requested by the California Fish and Game Commision (FGC) and the California Department of Fish and Wildlife (CDFW), coordinated an external, independent peer review to support the design of a recreational red abalone fisheries management plan (FMP). From June-October 2018, a peer review panel evaluated the scientific merits of two proposed management strategies. In an effort to promote open lines of communication and engage in information sharing with members of the red abalone community, OST, in partnership with the peer review co-leads and panelists, convened a public webinar on August 20, 2018 to:

- Learn about and discuss the red abalone community's science-based and research questions;
- Share information regarding the peer review process, including the data and questions that are currently being considered by the reviewers; and
- Build collective understanding of how the peer review aligns with the FMP process, including timelines and additional engagement opportunities.

Prior to the webinar, OST invited red abalone community members to submit their science-based and peer review process questions. More than 50 questions were received prior to August 20. Responses to these questions became the foundation for the webinar discussion and additional questions were also asked during the webinar (see Appendix 1 for complete list of questions received). Over 70 community members participated in the webinar.

The following document provides an overview of the questions asked and discussion topics and ideas that emerged from the webinar. This summary is intended to capture high-level details and key themes, rather than a transcript of the discussion. A full recording of the presentation, along with documents discussed during the webinar, are available on the Recreational Red Abalone Peer Review webpage on OST website.

Please contact Errin Ramanujam, OST, with any additional questions and comments: errin.ramanujam@oceansciencetrust.org.

I. Background Information

About Ocean Science Trust

- OST is an independent nonprofit based in Oakland, California. OST is not a government agency, and has no regulatory or management authority. Rather, OST is legislatively mandated to provide independent science to the State of California.
- With the main objective of providing sound, rigorous science to assist managers, policy makers, and community members in decision-making, OST does not advocate for particular policy or regulations. The organization frequently develops and delivers science in close collaboration with academic, federal and state scientists, and community members.

Recreational Red Abalone Fishery

- A primary goal of fishery management under the Marine Life Management Act (MLMA) is to ensure that fishing levels are sustainable and do not result in an overfished stock. This includes the recreational red abalone fishery. While past landings from 2002-2011 appear to be stable, recent declines in subtidal stocks have been recorded and the fishery was closed December 7, 2017.
- Red abalone has several characteristics which make it vulnerable to fishing pressure and environmental fluctuations. Recent declines and concerns about changing ocean conditions have prompted CDFW to develop a Recreational Red Abalone FMP to improve data collection and support timely management response.
- Proposed management strategies to be included in an FMP are required by the MLMA to undergo external, independent peer review prior to submission to the FGC. The peer review process provides CDFW, the FGC, and stakeholders assurances that FMPs are based upon the best readily available scientific information.
- Currently, there are two proposed management strategies being considered for incorporation into a Recreational Red Abalone FMP:
    - A management strategy proposed by CDFW
    - A stakeholder submitted management strategy, led by The Nature Conservancy (TNC)

Peer Review Process

- As noted in the 'Overview' section of this document, OST, with support from the Ocean Protection Council (OPC), was requested by the FGC and CDFW, to coordinate an external, independent peer review of the two proposed management strategies.
- A scientific peer review panel of seven scientists was selected by the OPC Science Advisory Team (SAT) Executive Committee. The peer reviewers specialize in a range of disciplines including fisheries science, ecology, oceanography, population dynamics, etc.
- The peer reviewers' responsibility is to review the science presented in the two management strategies and evaluate each approach to make sure the management strategy that gets incorporated into the FMP will use the best available science to inform management decisions. All aspects of both proposed strategies were reviewed, including how each will support a robust FMP individually, as well as how the ideas presented across strategies could complement each other.

II. Key Themes Summary of Questions & Responses

The majority of the questions received in advance of the webinar mirrored topics, or 'bins," that reviewers are considering during the peer review process. These included:

- How the peer reviewers are approaching their review of the two plans
- Indicators and changing ocean conditions
    - Productivity indicators
        - Density indicators
        - Reproductive indicators (gonad and body condition)
    - Length-based Spawning Potential Ratio (LB-SPR) & catch maximum sustainable yield (catch-MSY)
    - Environmental indicators
    - Indicators under different scenarios
- Management measure effectiveness

In addition to the questions received prior to the webinar, those who participated in the discussion on August 20 also were invited to share their science-based and process related questions. The following 'Questions and Responses' section considers all questions that were asked prior to and during the webinar (see Appendix 1 for a complete list of questions received from members of the red abalone community).

Peer Review Approach to Two Management Strategies

Participants asked how peer reviewers are considering the two management strategies and if they are considering ways to integrate the strategies.

- The peer reviewers are approaching this unique review holistically. They have been tasked with illuminating the scientific strengths and weaknesses of each plan, along with the ability to provide any recommendations for improvements for each management plan or identify clear areas of synergy between the two documents.
- The peer reviewers are identifying areas where both plans could be strengthened by utilizing components of the other plan. In addition, they are also thinking through scientific recommendations about how to strengthen components of each plan independently of the other.

Indicators and Changing Ocean Conditions

Productivity Indicators- Density

Density survey design and methods: Participants asked for clarification on red abalone survey design methods, the differences between the "rapid" assessments and the standard density assessments, whether CDFW changed their density protocol since 2014, and whether changing the survey protocol during the baseline years (2002-2007) or after that period changes the ability to make comparisons between years.

- The peer review is looking into the accuracy and reliability of the density survey estimates as it relates to the CDFW submitted management strategy. This includes investigating the precision with which data are informing management decisions at different spatial scales.
- Peer reviewers discussed how density, when surveyed accurately, can be used as a proxy for nearest-neighbor measurements. This is important for red abalone due to their need to be within a certain short distance of other abalone for successful spawning events.
- The cryptic nature of red abalone has been addressed through survey methods that require thorough counting by divers.

- Standard surveys collect information on habitat as well as numbers, while rapid surveys focus on the numbers.
- Density as an indicator is used differently in the draft management strategy submitted by CDFW than it was previously used. For example, to account for the implementation of marine protected areas (MPAs), CDFW modified baseline density estimates for areas that previously allowed the take of red abalone and now overlap with no-take MPAs.
- Reviewers are also looking into how both rapid and standard density surveys are being used to make management decisions.

Density as an indicator for setting target catch (CDFW proposed management strategy): Participants asked whether the density survey methods, data collection, estimates, and analysis are robust enough to manage the fishery in a timely manner. In particular, participants wanted to know if the way CDFW uses density in their proposed management strategy qualifies as a scientifically and statistically robust indicator.

- The peer reviewers are considering the use and reliability of density estimations provided in both management strategies.
- Typically, density is a good indicator of a healthy red abalone population, but the peer reviewers are reconciling whether the density estimations and the use of their results are scientifically sound as currently described in both management strategies.

Baseline density to set target catch (CDFW proposed management strategy): Participants asked whether the baseline that was established by CDFW using data from 2002-2007 is scientifically accurate and robust.

- Peer reviewers are considering the degree of accuracy needed for the baseline given current and past recorded red abalone landings. The peer review is ascertaining whether the level of resolution and the population that was present in 2002-2007 is the level needed to be considered sustainable.

Density and the TNC-led stakeholder proposed management strategy: Participants asked about the TNC-led stakeholder proposed harvest control rule (HCR) and whether the proposed management strategy incorporates the density-dependence of abalone into any of the strategy's analysis or operating models. If this is not the case, participants were also interested in learning whether not including density-dependent data is scientifically supported given the biological need for abalone to be close to one another for successful reproduction.

- The peer reviewers are looking at this question when reviewing the TNC-led stakeholder proposed management strategy, including determining the need for additional information about red abalone density-dependence at low population levels.
- The panel is also considering how removing density-dependent data from the analysis/models may impact the proposed management strategy, what the implications may be, and if the inclusion of other indicators is warranted.

Density as an indicator under changing ocean conditions: Participants asked how movement of abalone from the deep to nearshore environments affects density estimates and how different size classes are handling food loss.

- The peer reviewers explained that conditions have changed in the last couple of years since the two proposed management strategies were developed.
- While regional environmental conditions have led to the starvation and, due to lack of food, there appears to have been a a migration from subtidal to very shallow regions. This movement could be a change due to migration of abalone seeking out food in the intertidal areas.

- Data suggests that all age classes of red abalone seem vulnerable to starvation and there is no size bias for food loss.

Reproductive Indicators (Gonad & Body Condition)

Participants asked about the reproductive indicators included in the CDFW proposed management strategy (e.g., gonad size & body condition) and whether there is a scientifically proven link between body mass index estimates, gonad size, and the potential for abalone to reproduce. Also, participants asked if there is a scientific basis to changing the size limit to greater than seven inches to improve the reproductive capabilities of abalone.

- The peer reviewers explained that in theory, there is a relationship between body size and the number of babies an abalone can produce. This relationship would be dependent on a healthy population of abalone that are located close together.
- If the shell is big, but the body condition is poor, then the animal might not be able to reproduce. Consequently, shell size may not be linked to reproductivity.
- In theory, increasing the take size of red abalone should increase the number of gametes, which should in turn increase the number of babies. But this also assumes that abalone are healthy and located in close proximity to one another.

Length-based Spawning Potential Ratio (LB-SPR) & Catch Maximum Sustainable Yield (catch-MSY) Indicators

Participants asked if the TNC-led HCR and its components, LB-SPR and catch-MSY, are a scientifically sound approach to managing a fishery, if it is affected by the movement of abalone, and whether it would protect against the harvest of depleted populations under unfavorable recruitment or abundance conditions.

- The peer reviewers are considering all of these questions.
- The peer reviewers are looking into how LB-SPR is used in the HCR proposed by the TNC-led stakeholder management strategy. The peer reviewers are investigating how this indicator operates in a fishery with life history traits like red abalone.
- The peer review panel has looked at the TNC HCR simulation results from the Management Strategy Evaluation and is still reviewing how the simulation results may vary under different recruitment results and natural mortality scenarios.
- The peer reviewers are also investigating the TNC HCR and its simulation testing outputs with relation to how the management strategy operates at high and low densities of abalone.

Environmental Indicators

Participants asked if the environmental indicators and triggers set in the CDFW proposed management strategy (kelp canopy, water temperature, and urchin densities) are accurate and scientifically rigorous . In addition, participants asked how red abalone populations inside MPAs, and the role of MPAs more generally, factor into population estimates, the impacts of fishing, and environmental conditions.

- The peer reviewers are considering all of the environmental factors mentioned and how they could be used in a management strategy. Kelp canopy, water temperature, and urchin densities are known to have dramatic impacts on populations and the peer reviewers are investigating the scientific underpinnings of these as indicators in a management strategy.
- The population size in MPAs could be used as a reference point for populations outside of MPAs where the harvest of red abalone is permitted. The peer review panel is considering the best way to use MPAs as a reference point.

- The peer review panel is evaluating the methods proposed for utilizing the environmental indicators and triggers and how they will respond to changing ocean conditions. It is not within the scope of this peer review to consider how CDFW will address future ocean conditions through changes in survey method or in management response.

Indicators Under Different Scenarios

Abalone Recovery & Re-opening: Participants asked how long will it take for red abalone populations to recover, whether using historic density levels to establish criteria for reopening the fishery makes sense considering the long-term impacts of global warming, and if a new reduced criteria should be used to establish a sustainable fishery at a smaller abalone density and catch level. Participants also asked if different elements of reopening under the CDFW proposed management strategy are scientifically sound and robust, including the thresholds for tracking changes in the population and how they are used to make management decisions about reopening.

- Peer reviewers are considering these questions, however it is unlikely the questions will be addressed during the review because more information needs to be gathered to understand what the answers are.
- The idea of allowing very low catch levels is a management question. Science can help managers and community members understand population levels and assess impacts to stock at various levels of take (although this question is outside the scope of this peer review), but the decision to allow access and determine the level of risk to damaging the stock is ultimately a management decision.
- The peer review panel considers reopening to be part of the scope of the review and has asked CDFW and TNC how they could include metrics that take reopening into consideration. The panel is will review any additional information received from CDFW and TNC.

Kelp: Participants asked whether the fishery should be completely closed until kelp beds return.

- Kelp is an indicator in the CDFW proposal, but the peer reviewers noted that the proposed way to assess kelp is based on aerial photographs of the coastline, yet several kelp species are not viewable from the air. The peer reviewers are considering this information to assess if kelp, as proposed, is a scientifically rigorous indicator.

General: Participants asked about priority gaps in research and monitoring and whether CDFW will be able to collect and maintain the information necessary to achieve management targets for the stocks. In addition, there was interest in understanding how both proposed management strategies are taking into account the different habitats in fished areas.

- The peer review panel has not been tasked with identifying priority gaps in research.
- Peer reviewers are considering the habitat and spatial components included in both proposed management strategies.

Management Measure Effectiveness

Participants asked whether the different management measures proposed in both proposed management strategies are effective at regulating catch, viable for dealing with poaching, and consider the possibility of urchin culling for restoration.

- Evaluating management measures, including enforcing poaching and removing urchins, are outside the scope of this review. Participants are encouraged to reach out to Sonke Mastrup, CDFW Environmental

Program Manager, Invertebrate Program, with thoughts and questions. He can be reached at Sonke.Mastrup@wildlife.ca.gov. Participants are also welcome to bring these types of questions to upcoming Fish and Game Commission meetings where the Recreational Red Abalone FMP will be discussed (schedule here).

Additional Areas of Interest Identified During the Webinar

Participants had additional questions that were not addressed during the webinar. These included questions about monitoring, data sharing, and additional clarifications about current and proposed methodologies. Many of these questions will not be addressed by the peer review. As mentioned above, CDFW encouraged participants to reach out to Sonke Mastrup and/or bring these types of questions to upcoming Fish and Game Commission meetings.

Appendix 1: Community Questions

Peer Review Approach to Two Management Strategies

- How are the peer reviewers thinking about their review of the two management strategies?
- Are the peer reviewers thinking about ways to integrate the plans?
- How will the peer review inform management decisions once completed?

Indicators and Changing Ocean Conditions

Productivity Indicators

Productivity density survey design and methods

- How do the surveys consider the cryptic nature of abalone (e.g. some on top of rocks, others below)? How does this affect the reliability or accuracy of the density survey data?
- What are the differences between the "rapid" assessments and the standard density assessments and are they statistically directly comparable?
- Has CDFW changed their density protocol per the recommendations of the 2014 OST convened peer review? Has this addressed the concerns raised? If so, how scientifically robust and statistically significant are the density surveys the way the CDFW uses them in the current proposed management strategy/plan, both for overall density and for deep water density?
- Has there ever been a change in the protocol for density transects since the baseline data was collected from 2002-2007, and if so, what effects do those changes have on comparisons between the baseline period and subsequent years?
- What is the appropriate level of density data to acquire for it to be useful for making management decisions?
- How are changes in size limited related to nearest neighbor differences?
- How is the density indicator impacted by the population outside the center of the management area?

Using density as an indicator for setting target catch (CDFW plan)

- Are the density survey methodology, data collection, estimates, and analysis robust enough to use to manage the fishery in a timely manner? If not, how much more data would be required to achieve this? How much would it cost to gather this additional information?
- Is the way CDFW uses density in their proposed management strategy a scientifically and statistically significant indicator?
    - Are the more limited site-specific monitoring and control rule provisions sufficient to account for the spatial specificity of abalone population dynamics?

Density Indicators

Density as an indicator for setting target catch (CDFW plan)

- Is the baseline that has been established using data from 2002-2007 scientifically accurate and robust? Is there a scientific basis to continue using it?
    - Is there a chance that this baseline is artificially high due to the extinction of the abalone primary predator, sea otters, before this baseline period began?
    - Does fishing replace otters as the abalone main predator? How does the rate of fishing predation compare with otters?

Density and the TNC-led stakeholder proposal

- Does the TNC-proposed harvest control rule (HCR) incorporate the density-dependence of abalone into any of their analysis or operating models?

- Is the decision to eliminate density-dependent data scientifically supported given the biological need for abalone to be close to neighbors for successful reproduction?

Density as an indicator under changing ocean conditions

- How does the movement of abalone from deep water into nearshore environments impact the density estimates, including CDFW's use of deep water transects as part of that density estimate methodology?
    - Does the movement of abalone out of the deep water refuge change how CDFW thinks about maintaining a sustainable fishery?
    - How does this affect overall densities and their statistical reliability?
- How are the different size classes handling the loss of food? Is the loss of food affecting each size class differently?
- How does the reproductive potential of abalone at different sizes affect the indicator? Do abalone stop reproducing at certain sizes?
- How much do we know about gonad size and body condition as it relates to abalone reproduction?

Reproductive Indicators (Gonad & Body Condition)

Productivity – Reproductive

- For the reproductive indicators utilized by CDFW (e.g., gonad size & body condition), is there a scientifically proven link or relationship between the estimate of body mass index and the abalones ability to reproduce?
    - How about for gonad index?
- Is there a scientific basis to changing the size limit to greater than 7'' will improve the reproductive capabilities of abalone?
- Is the overall management target of maintaining 60% egg production appropriate and scientifically well supported?

Length-based Spawning Potential Ratio (lb-SPR) & Catch Maximum Sustainable Yield (MSY) Indicators

- Does the movement of abalone affect the way the TNC HCR works?
- Does the TNC HCR represent a scientifically sound approach to managing a fishery? Would it potentially allow harvest on depleted populations or under unfavorable recruitment or abundance conditions?
- How is MSY determined with length based SPR when the abalone is atrophied and how would that information be applied for viable abalone management measures?

Environmental Indicators

- Are the environmental indicators and triggers set in the CDFW proposed management strategy accurate and scientifically rigorous (eg. kelp canopy, water temperature, and urchin densities)?
- How do the MPAs and populations inside the MPAs factor into the population estimates and the impacts of fishing and environmental conditions? Could population dynamics inside the MPAs bound models?
- Do these environmental indicators or the way they are used allow for changes in survey methods if there are changes in the environment in the future? Is there a public process before these changes in methodologies could occur?
- Will the peer reviewers be assessing each environmental indicator?
- How scientifically viable are the thresholds associated with each indicator? Should there be a range rather than a specified number?

Indicators Under Different Scenarios

Abalone Recovery

- How long will it take for the population to recover? How long will it take for abalone to recover to a density greater than .45/m2?
- Considering the likely, long-term impacts of global warming, is it defensible to use historic density levels to establish criteria for reopening the fishery? Should new, reduced criteria be used to establish a sustainable fishery at a smaller abalone density and catch level?
    - Is it possible to manage the fishery to a much lower level of take and have it be sustainable and/or recover to better levels over time?
    - What additional science/data would be required to assess the risk of reopening the fishery?
    - Are the trade-off considerations between catch reductions and recovery discussed in the TNC report (and elsewhere)? Is this proposed approach well-founded and appropriate? Is 25 years a suitable recovery timeframe?

Abalone Fishery Reopening

- Are the different elements of reopening under the CDFW plan scientifically sound and robust?
    - What is the mechanistic link between the environmental and density (> 0.25 m2) thresholds set by CDFW and the stock status of abalone, and how does the CDFW explicitly define favorable, as they relate to fishery reopening?
    - What is the scientific relevance of the size class distributions as outlined in the plan (i.e. sub-legal sized population of abalones be >30% of the total population and that legal sized abalone have a population >40% of the total)?
    - What research or analyses are available to inform the choice of thresholds for these environmental indicators (under reopening especially) to demonstrate that they are "favorable"?
- Are the thresholds scientifically robust and relevant for tracking changes in the population and making management decisions about reopening?

Kelp

- Should the fishery be completely closed until kelp beds return?

Indicators Under Different Scenarios — General

- Are research and monitoring needs comprehensive to allow CDFW to collect and maintain essential fishery information necessary to achieve management targets for the stock?
- Are there any priority gaps in research and monitoring that should be addressed or included?
- How are both plans taking into account the different habitats in the areas fished. For example, the differences between Humboldt/Del Norte areas vs. Sonoma/Mendocino counties?

Management Measure Effectiveness

- Are the different management measures proposed effective at regulating catch?
- Are the measures and enforcement that CDFW has viable for dealing with poaching of red abalone?
- Will urchin culling in select areas restore the diversity of marine life and act as sanctuaries from urchins to repopulate the coast when conditions improve?

Additional Areas of Interest

- Where does monitoring fit? While monitoring is likely addressed within many of the bins, I wonder if the subjects of data management and data sharing are included in the management plan?
- Concerns expressed that there is limited public trust in how CDFW has considered density in the past.

Terms of Reference

Red Abalone Fishery Management Plan Management Strategy Scientific Peer Review Process

2018

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Developed by California Ocean Science Trust on behalf of the California Department of Fish and Wildlife and The Nature Conservancy, 2018. Funding provided by California Ocean Protection Council.

Contents

1. Introduction

1.1. Management Context

The northern California populations of red abalone support a very popular recreational fishery throughout northern California. While past landings (2002-2011) appear to be stable, recent declines in subtidal stocks have been recorded and the fishery is now closed. Red abalone has several characteristics, which make it vulnerable to fishing pressure and environmental fluctuations.

In 2005, the Fish and Game Commission (FGC) adopted the Abalone Recovery and Management Plan (ARMP), which governs the management of the recreational red abalone fishery and recovery of southern abalone stocks. This plan sets management guidelines and triggers for Total Allowable Catch (TAC) adjustments based on 2 criteria – density and recruitment. The ARMP has two phases of adaptive management: the interim management plan which the fishery is currently managed under, and the long-term management plan. The interim plan manages the northern California fishery as a single unit on a highly precautionary basis. The ARMP objective is to move the fishery into long-term management, where management is locally based, more responsive and adaptive, while maintaining sustainability. Management changes to the fishery in 2014 marked the beginning of this move to long term management conceptually by differing regulations between southern and northern areas of the fishery. The transition to ARMP long-term management provides an opportunity for the California Department of Fish and Wildlife (CDFW) to move management of the recreational red abalone fishery to a fishery management plan (FMP) under the Marine Life Management Act (MLMA).

A primary goal of fishery management under the MLMA is to ensure that fishing levels are sustainable and do not result in an overfished stock. Recent declines and concerns about changing ocean conditions have prompted the need for more information and a quicker management response, which the long-term management under an FMP seeks to provide for this fishery. FMPs assemble information, analyses, and management options that serve as a vehicle for the CDFW to present a coherent package of information, and proposed regulatory and management measures to the FGC. The FMP becomes effective upon adoption by the Commission, following their public process for review and revision.

Thus, it is important for the scientific underpinnings of the draft FMP to undergo external, independent peer review prior to submission to the FGC. This process is one way to provide FGC and stakeholders assurances that FMPs are based upon the best readily available scientific information, as set forth under the MLMA. The FGC and CDFW have asked for both the management strategy proposed by CDFW and a stakeholder submitted management strategy, led by The Nature Conservancy (TNC), to be included in the peer review. Each of the groups have provided an independently developed management strategy for consideration.

1.2. Review Process Goals and Objectives

Ensuring the best use of best available information in fisheries management is an important tenet of the MLMA. The MLMA identifies external scientific review as a key tool to ensure management decisions are based on the best available scientific information. CDFW is committed to incorporating the best available scientific information into fisheries management through a peer review process.

Scientific and technical peer review (review) is widely applied across numerous technical disciplines to assure products are of high quality, reflect solid scholarship, and that the information contained is accurate and based on rigorous, sound scientific methods (OST 2016). In any review, Ocean Science Trust's (OST) intent is to provide an assessment of the work product that is balanced, fairly represents all reviewer evaluations, and provides feedback that is actionable. When building a review process, OST seeks to balance and adhere to six core review principles: scientific rigor, transparency, legitimacy, credibility, salience, and efficiency. These principles ground the review and shape the products that we develop.

As such, the goals and objectives of the FMP review process are to:

1. ensure that the science underpinning the FMP represents the best scientific information available and is appropriately used to inform a harvest control rule;
2. follow a detailed calendar and fulfill explicit responsibilities for all participants to produce required reports and outcomes;
3. provide an independent external scientific and technical review of the agreed upon sections of the red abalone FMP;
4. use review resources effectively and efficiently.

1.3. Review Coordinating Body: Ocean Science Trust

Ocean Science Trust is an independent non-profit organization working across traditional boundaries to bring together governments, scientists, and citizens to build trust and understanding in ocean and coastal science. We empower participation in the decisions that are shaping the future of our oceans. We were established by the California Ocean Resources Stewardship Act (CORSA) to support managers and policymakers with sound science.

For more information, visit our website at www.oceansciencetrust.org.

Contact information

Errin Ramanujam, California Ocean Science Trust (errin.ramanujam@oceansciencetrust.org)

2. Peer Review Scope and Process

2.1. Review Request

CDFW and FGC's purpose in asking OST to conduct a review of the scientific and technical components of both the CDFW and the TNC management strategy is to ensure the scientific and technical elements provide a rigorous underpinning for management decisions and regulatory action should they be implemented. Ocean Science Trust is serving as the review coordinating body, and worked with CDFW and TNC to develop a scope of review that focuses on key scientific and technical components of the management strategies where independent scientific assessment would add value (this document). Components subject to review were determined using criteria from OST 2017 (here).

2.2. Scope of review

CDFW is seeking an independent assessment of the red abalone management strategy developed by CDFW, as well as the stakeholder-submitted management strategy led by TNC.

The central question of this review is:
Are the underlying data and analysis, and application of those in each of the proposed management strategies scientifically sound, reasonable and appropriate while also meeting the management goals for the recreational red abalone fishery in northern California as defined by MLMA?

The review will focus on evaluation of the following components of both management strategies:

- Evaluation of the data collection methods that inform management indicators, triggers, and decisions including informing responses to changes in the environment, fishing, or other stressors.
- What is the scientific rationale for the indicators used and their link to responses in the abalone population?
- Is the proposed quantitative analysis and application of the data scientifically rigorous and is the scientific rationale for the proposed management actions it triggers accurate?
- Evaluation of modelling approach used including model assumptions, analyses, interpretation, and application of the model results to evaluate performance of the harvest control rules against management objectives.

- From a scientific perspective, provide a general assessment of the proposed methodologies including application, assumptions, and management implications of uncertainties in the stock status, data streams, and analytical method within the confines of CDFW capacity and regulatory authority

For clarity we note that this is not a comprehensive review of the entire FMP. Rather, we are reviewing only the management strategies submitted by TNC and by CDFW.

2.3. Process

Review Process Overview

- **Select a review mode.** A review process is selected in consultation with CDFW, Ocean Protection Council, and any other relevant groups (contractors, authors, etc.) by considering complexity, management risk, uncertainty, socioeconomics, level of previous review, and novelty (OST 2016; OST 2017).
- **Assemble review team.** Ocean Science Trust will convene a ~6 member review panel composed of Ocean Protection Council Science Advisory Team members and other experts (see "Assembling a Review Team," OST 2016 and "assembling a review team" below for additional details).
- **Conduct review via a series of webinars.** Group webinars will allow CDFW and TNC to engage directly with reviewers at the outset to present the inputs, model methods, and application of analyses and provide two-way interaction to provide any additional clarity needed to complete the review. Many of the webinars will allow for independent deliberation and conversation among reviewers. Given the timeline no in person workshop will be convened.
- **Develop and share final report.** Reviewers will contribute to the development of a final report, which will be made available on OST and CDFW webpages.
- **Review process**: A single peer review panel will review both the CDFW management strategy and the stakeholder-submitted management strategy at the same time. CDFW, FGC, TNC, and OPC formally requested OST to conduct the review in this way. There will be one summary report will be submitted which covers both management strategies.

Review Mode: Remote Panel Review

All meetings will take place via remote online meetings (webinars). At the outset of the review, OST will work with CDFW and TNC to develop detailed reviewer instructions that encourage focused scientific feedback throughout the process. Instructions will include directed evaluation questions and may delegate tasks for reviewers based on their individual areas of expertise. This document will be used to guide the development of meeting agendas and track progress throughout the course of the review. For each meeting, advance work will be required of participants (e.g. drafting responses to guiding

questions) in order for all parties to come prepared for meaningful discussions. OST will notify CDFW and TNC of additional requested materials and data immediately throughout the duration of the review.

Webinar 1: Initiation of Review

Ocean Science Trust will host an initial webinar to provide the review committee, CDFW, and TNC an overview of the scope and process, and clarify the roles and responsibilities of each participant. CDFW will also provide a summary of the relevant management context to ensure reviewers understand the role of the review in the larger FMP development process, and how the outputs will be considered. The bulk of the webinar will then focus on a presentation by CDFW and TNC of the scientific and technical components of each management strategy. This webinar is an opportunity to develop a shared understanding of the tasks and allow reviewers to ask CDFW and TNC any clarifying questions about the review materials or request additional materials before they convene independently to conduct their technical assessment.

Webinar 2-3: Reviewers convene with OST to conduct review

Ocean Science Trust will convene approximately two remote two to three-hour webinars with the review committee to conduct an in-depth evaluation of the components identified in the Scope of Review (above). In advance of each webinar, reviewers will be asked to prepare responses to guiding evaluation criteria questions specified in the review instructions. During each webinar, reviewers will discuss their findings and develop conclusions and recommendations within the context of these questions. Additional follow-up phone conversations may be scheduled as needed to complete the review. Outputs from each webinar, as well as reviewer responses to the questions, will guide the development of the final report.

Webinar 4: Final summary report feedback

Ocean Science Trust will host a final 2-hour webinar to gather final feedback and input from the review panel on the summary report. The review panel will be asked to review the draft summary report in advance of this meeting. This final meeting will provide a space for reviewers to voice any suggested edits or clarifications, and a chance to have a final discussion about results before sharing the final report with CDFW and TNC.

Assembling Reviewers

Transparency

Reviewer names will be published on OST's webpage for the review at the outset of the review; however, specific review comments in the final review report will not be attributed to individual reviewers.

Selection of Reviewers

Ocean Science Trust will implement a reviewer selection process to assemble a review committee composed of ~6 external scientific experts. Ocean Science Trust will consult with and solicit reviewer recommendations from CDFW, TNC, the Ocean Protection Council Science Advisory Team (OPC-SAT), as well as OST's own professional network among the academic and research community. Membership may include experts from academia, research institutions, and government agencies as appropriate to deliver balanced feedback and multiple perspectives. Reviewers will be considered based on three key criteria:

Expertise: The reviewer should have demonstrated knowledge, experience, and skills in one or more of the following areas:

- ecology of invertebrates and/or red abalone
- fisheries science and management (e.g. HCR, TAC, management triggers)
- modeling for fisheries management use (e.g. Management Strategy Evaluation)
- invertebrate and/or red abalone population dynamics and indicators specific to understanding the response to environmental, fishing, and other stressors
- sampling and data collection methods for invertebrate and/or red abalone population studies
- statistical analysis methodologies

Objectivity: The reviewer should be independent from the generation of the product under review, free from institutional or ideological bias regarding the issues under review, and able to provide an objective, open-minded, and thoughtful review in the best interest of the review outcome(s). In addition, the reviewer should be comfortable sharing his or her knowledge and perspectives and openly identifying his or her knowledge gaps.

Conflict of Interest: Reviewers will be asked to disclose any potential conflicts of interest to determine if they stand to financially gain from the outcome of the process (i.e. employment and funding). Conflicts will be considered and may exclude a potential reviewer's participation.

Final selection of the review committee panel will be made by the OPC-SAT Executive Committee. Ocean Science Trust will select one member of the review committee to serve as chair to provide leadership among reviewers, help ensure that all members act in accordance with review principles and policies, and promote a set of review outputs that adequately fulfill the charge and accurately reflect the views of all members.

Transparency in the Review Process

Once selected and shared with the CDFW and TNC teams, Ocean Science Trust will publish this terms of reference document to our website. OST will reach out to key communicators to share the website information and alert them to the review. Upon delivery of the final report to CDFW, the report will also be made public on the OST review webpage. OST will then host a webinar with key members of the review team to share results of the review with any interested stakeholders. CDFW and TNC may participate in this webinar at their discretion.

Management Preview and OPC-SAT Endorsement

Ocean Science Trust will share the final summary report with CDFW and TNC for a preview before the review results are published and shared with the public. There will be an opportunity for CDFW and TNC to ask clarifying questions of the review committee and for reviewers to make clarifying edits only, as appropriate. This may occur via email, conference call or short webinar as time allows.

As a product of the OPC-SAT, near-final reports must go through a full OPC-SAT endorsement before public release.

2.4. Review Report (reference appendix template)

Ocean Science Trust will work with reviewers to synthesize reviewer assessments (responses to the review instructions and input during webinars) into a cohesive, concise final written summary report. This review summary will be delivered to CDFW by xxx 2018, and made publically available on OST's website. We acknowledge that reviewers may provide recommendations beyond the given reviewer charge; such recommendations will be honored and represented in the final summary as deemed appropriate by the review panel.

2.5. Timeline

The review will commence May 2018 with the expected delivery of a final summary report to CDFW by August 2018. A timeline of each task is provided below.

	April	**May**	**June**	**July**	**Aug**	**Sept**
Receive Draft FMP			June 1			
Terms of Reference Development (April-May)		X				
Develop and Finalize Terms of Reference	X	X				

Assemble Review Team and Develop Guidance for Reviewers (April - May)	X	X				
Develop/put up webpage		X	X			
Solicit, select, and confirm reviewers	X	X				
Schedule webinars		X	X			
Develop Review Instructions	X	X				
Develop webinar agendas		X	X	X	X	
Conduct Review (June-August)						
Distribute TOR, review materials, and Review Instructions to reviewers			X			
Kickoff webinar			X			
Webinar 2			X	X		
Webinar 3				X	X	
Final Webinar					X	
Additional data requests to DFW/TNC			X	X		
Develop outline and draft report, edits from reviewers					X	
Final draft to reviewers					X	
Final edits					X	
Management preview					X	
Final Report to DFW						X
Post final report on OST website						X
Follow-up as appropriate						X

3. Roles and Responsibilities of Peer Review Participants

3.1. Shared Responsibilities

All participating parties share the responsibility in assuring adequate technical and scientific review of the Red Abalone management strategies in accordance with the MLMA.

3.2. Reviewer Responsibilities

The role of the review committee is to conduct a detailed evaluation of the scientific underpinnings of aspects of both the Red Abalone management strategies, where external review will be valuable. The specific responsibilities of the review committee are included in the Review Instructions. The review committee may request additional information, data, and analyses as appropriate to support a comprehensive and useful review.

The review committee chair has, in addition, the responsibility to: 1) provide leadership among reviewers; 2) ensure that review committee participants follow the terms of reference, adhere to the charge for the review, and review instructions and guidelines; and 3) promote review outputs that adequately fulfill the charge and accurately reflect the views of all members.

The review committee is required to make an honest and legitimate attempt to resolve any areas of disagreement during the review process. Occasionally, fundamental differences of opinions may remain between reviewers that cannot be resolved. In such cases, the review committee will document the areas of disagreement in the final summary report.

Selected reviewers should not have financial or personal conflicts of interest with the scientific information, subject matter, or work product under review within the previous year (at minimum), or anticipated. Reviewers should not have contributed or participated in the development of the product or scientific information under review. Review committee members who are federal employees should comply with all applicable federal ethics requirements. Reviewers who are not federal employees will be screened for conflicts of interest.

3.3. CDFW and TNC Team Responsibilities

CDFW and TNC will participate in the review process as follows:

1. *Provide all relevant project documents, data, and supporting materials.*

   a. Identify and provide all project documents, data, and other information necessary for reviewers to conduct a constructive assessment.
   b. Work to ensure all related materials are clear and accessible to reviewers in a realistic timeframe and respond to additional requests in a timely manner.
2. *Constructively engage with reviewers and OST staff, and respond to data and other information requests in a timely manner.*
   a. Engage in the process and be available to answer questions or present materials to the review committee as necessary.
   b. Sonke Mastrup (CDFW) and Alexis Jackson (TNC) will serve as the primary contacts during the review process. In order to adhere to review timelines, CDFW and TNC will respond to and provide feedback on requested materials from OST in a reasonable, mutually agreed-upon timeframe.
3. *Consider reviewer comments and recommendations.* CDFW, FGC, and TNC intend to consider and incorporate reviewer feedback and recommendations into the management strategy for the FMP and supporting materials as appropriate.

3.4. Ocean Science Trust Responsibilities

California Department of Fish and Wildlife, FGC, and TNC have requested OST to serve as the independent appointed entity to design and coordinate all aspects of this scientific and technical review. Ocean Science Trust will design and implement all aspects of the review process to meet management needs, including assemble and guide a committee of expert reviewers, conduct a review process that is on task and on time, schedule and host remote meetings as appropriate, work with reviewers to produce a written final summary report, and encourage candor among reviewers, among other activities. Upon completion of the review, the final report will be delivered to CDFW and TNC and made publicly available on the OST website for all constituents. Throughout, OST will serve as an honest broker and facilitate constructive interactions between CDFW, TNC, and reviewers as needed in order to ensure reviewers provide recommendations that are valuable and actionable, while maintaining the independence of the review process and outputs.

Appendix: Outline of Example Peer Review Report

The following is an example template for a peer review report:

1. Summary of the Peer Review Committee, containing:
   a. Names and affiliations of committee members
   b. Topic(s) being reviewed
   c. List of analyses requested by the Committee, the rationale for each request, and a brief summary the responses to each request

2. Comments on the technical merits and/or deficiencies in the applications of the analyses underpinning the FMP and recommendations for remedies. Comments should address issues such as the following:
    a. What are the data requirements of the analyses underpinning the FMP?
    b. What are the situations/stock status for which the analyses are applicable?
    c. What are the assumptions of the methodology and/or in applying the proposed analyses?
    d. Are the methodology and application of the analyses correct from a technical perspective?
    e. How robust are results to departures from the assumptions of the analyses?
    f. Do the application of the analyses take into account estimates of uncertainty? How comprehensive are those estimates?
    g. Will the new analyses and application of analyses result in improved stock assessments or management advice?

3. Areas of disagreement regarding panel recommendations:
    a. Among panel members
    b. Between the panel and proponents
4. Unresolved problems and major uncertainties (e.g., any issues that could preclude use of the analyses underpinning the FMP)
5. Management, data, or fishery issues raised by the public and other representatives during the panel review
6. Prioritized recommendations for future research and/or data collection