Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

Marine Protected Area Climate Vulnerability Assessment Guide

January 2023

https://sanctuaries.noaa.gov/management/climate/

U.S. Department of Commerce
Gina Raimondo, Secretary

National Oceanic and Atmospheric Administration
Richard W. Spinrad, Ph.D., Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator

National Ocean Service
Nicole LeBoeuf, Assistant Administrator

Office of National Marine Sanctuaries
John Armor, Director

SUGGESTED CITATION

Cannizzo, Z. J., Hutto, S., Lonhart, S., Grant, K., & Neuberger, J. (2023). Marine Protected Area Climate Vulnerability Assessment Guide. National Oceanographic and Atmospheric Administration, Office of National Marine Sanctuaries.

Cover photo: A researcher studies the reefs of Papahānaumokuākea Marine National Monument. Photo: OET/NOAA

Table of Contents

Acknowledgements

The Office of National Marine Sanctuaries (ONMS) would like to thank the ONMS Climate Team Science and Assessment Working Group for drafting this guidance document. Our sincere thanks are extended to the drafting team Zachary Cannizzo, Climate Coordinator at the National Marine Protected Areas Center/ONMS Headquarters; Sara Hutto, Conservation and Climate Program Coordinator at the Greater Farallones Association/Greater Farallones National Marine Sanctuary; Steve Lonhart, Research Ecologist at Monterey Bay National Marine Sanctuary; Kevin Grant, Superintendent of Olympic Coast National Marine Sanctuary; and Jillian Neuberger, Climate Associate at the National Marine Sanctuary Foundation/the National Marine Protected Areas Center/ONMS Headquarters, as well as working group members Steve Gittings, Science Coordinator at ONMS Headquarters; Madeline Roth, CPC Maritime Archaeologist under contract to ONMS HQ; Jennifer Selgrath, Social Scientist and Spatial Ecologist at CPC/Channel Islands National Marine Sanctuary; Tammy Silva, Research Marine Ecologist at Stellwagen Bank National Marine Sanctuary; Tane Casserley, Resource Protection and Permit Coordinator at Monitor National Marine Sanctuary and Mallows Bay – Potomac River National Marine Sanctuary; Valerie Brown, Research Coordinator, National Marine Sanctuary of American Samoa; Kayla Williams, Sea Grant Knauss Fellow at the National Marine Protected Areas Center/ONMS Headquarters; Randall Kosaki, Research Ecologist at Papahānaumokuākea Marine National Monument; and Lauren Wenzel, National Marine Protected Areas Center Director/ONMS Headquarters. From initial drafting through to publication, the guide also benefited substantially from expertise across the Sanctuary System, including support from staff at sites and headquarters. The authors would like to particularly thank the document's many reviewers, who's insight significantly enriched the final product.

Chapter 1: Introduction

National marine sanctuaries and other protected areas have traditionally managed the resources under their stewardship trusts with the assumption that past environmental conditions can provide a reasonable approximation of future states. This dependence on understanding the past to manage for the future has served protected area managers well for decades. However, as global climate change causes temperatures and sea levels to rise, waters to acidify and deoxygenate, and species to move to new areas, the forces structuring the ecosystems and resources within protected areas will be more complex than past conditions. Therefore, a reliance only on the past to understand the future is no longer a viable management approach. Rather, responsible resource management requires anticipation of, and planning for, future conditions and novel ecosystems which may have no historical analogue.

Key to resource management under climate change is understanding the vulnerability of resources to potential future conditions. This climate vulnerability is a measure of a resource (e.g., species, habitat, place, ecosystem service, cultural or heritage resource) or human community's susceptibility to the impacts of one or more climate change and non-climate factors or stressors, hereafter referred to as "hazards."[1] The climate vulnerability of a resource is a function of the sensitivity of that resource to climate changes, its exposure to those changes, and its capacity to adapt to those changes (i.e., adaptive capacity) (Box 1; Figure 1). The process that resource managers use to evaluate the climate vulnerability of a resource or resources is called a "Climate Vulnerability Assessment."

Box 1: Components of vulnerability

Exposure is a measure of how much change in climate or another environmental hazard a resource or community is likely to experience.

Sensitivity is a measure of whether and how a resource or community is likely to be affected by a given change in climate or another environmental hazard.

Adaptive Capacity is a measure of the ability of a resource or community to adapt to the impacts of climate change or other hazards.

The *vulnerability* of a resource to a particular hazard is a function of its *adaptive capacity* to the hazard, and the *potential impact* of that hazard on the resource. The *potential impact* of a hazard on a resource is itself a function of the *exposure* and *sensitivity* of the resource to the given hazard (Figure 1).

[1] This guidance document adopts the Intergovernmental Panel on Climate Change definition of hazard as "the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources."

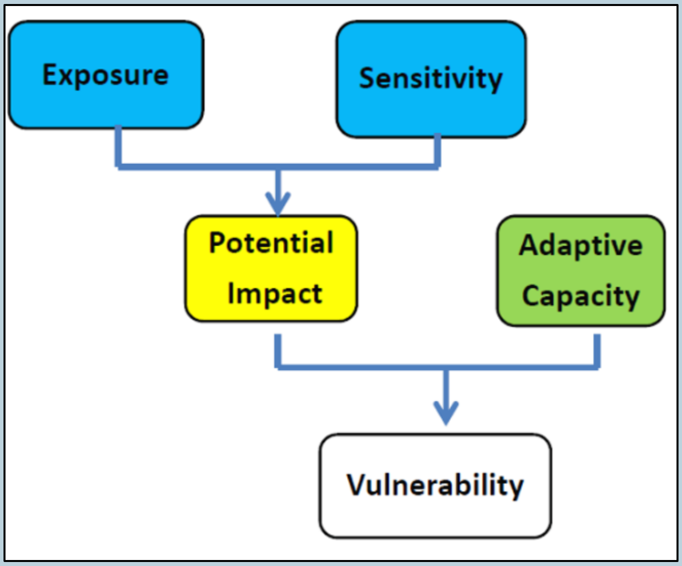

Figure 1. Flow chart of the components of vulnerability.
Image: NOAA

A *climate vulnerability assessment* (CVA) qualitatively describes and evaluates how climate and environmental hazards affect the vulnerability of a protected area's resources to climate change in order to inform and improve management approaches for long-term success. While a CVA alone cannot be used to make a management decision, it is an important tool that supports climate-informed management. A CVA enhances resource managers' understanding of which resources are most vulnerable to climate change, as well as why those resources are vulnerable. This climate-related knowledge supports management prioritization, and effective allocation of finances and capacity. In addition, it supports the development of management strategies that target the mechanisms driving resource vulnerability.

Typically, a CVA is conducted by a protected area or resource manager with broad participation from subject matter experts. To conduct a CVA, managers generally require:

- An interest in learning how climate change is affecting their site and/or resources;
- Knowledge of the site being evaluated (habitat types, basic ecological information, human communities served by the site, basic information about ecosystem services provided by the site, existing threats, management mechanisms, current status and trends)
- A list of key resources to be assessed (species, habitats, cultural resources and/or ecosystem services, adjacent and/or dependent human communities);
- Awareness of relevant climate impacts and hazards; and
- Access to basic climate information to support understanding of those impacts and hazards by CVA participants.

A CVA can be conducted at any time in a Marine Protected Area's (MPA's) planning process to inform climate-smart management. Ideally, a CVA is conducted before a MPA's management plan development or review process to help focus a site's priority management actions. If not conducted during management plan development or review, then CVAs should be conducted relatively early in the site's climate change management planning process, as they inform future actions and require only the basic resources listed above. In short, *managers should not wait for an "ideal" time to conduct a CVA*. Climate change is rapidly accelerating. The "ideal" time to conduct a CVA is as soon as the capacity and resources to do so are available.

For example, Olympic Coast National Marine Sanctuary (OCNMS), a federally-managed MPA in Washington State, conducted a CVA immediately following their condition report (a process which assesses the status of resource condition and trends in that status since the previous report) and before a management plan review. This enabled OCNMS to leverage newly analyzed resource status and trend data from the condition report process to identify resources to assess in the CVA. Moreover, the CVA informed OCNMS on the assessment of sanctuary resources and made climate vulnerability information available for the management plan review. In this way, the CVA was used to leverage current information about resources and projected future conditions in order to create climate-informed management action plans.

This document serves as guidance for MPA managers interested in implementing a CVA. It has been developed by NOAA's Office of National Marine Sanctuaries (ONMS) and highlights the processes and experiences gained by national marine sanctuaries over the course of almost a decade of conducting CVAs. While this guidance document focuses on the planning process of ONMS in order to provide a methodologically consistent set of examples, it is designed to be applicable to marine and coastal protected areas more broadly. In addition to providing an overview of processes that are of relevance to all CVAs, this document describes the processes involved in conducting two distinct scopes of CVAs, as well as guidance and considerations for choosing the best fit for a particular MPA. As such, while this document can be read in its entirety, it is designed to be modular and readers are encouraged to explore those sections that are of greatest relevance to their needs (see Table of Contents). It covers a range of topics including **understanding vulnerability** (Chapter 2); **selecting the scope of a CVA** (Chapter 3); **selecting focal resources, communities, timescales, and hazards** (Chapter 4); **selecting participants** (Chapter 5); **conducting the assessment** (Chapter 6); **developing adaptation strategies** (Chapter 7); **writing a CVA report** (Chapter 8); and **analyzing results and making the CVA actionable** (Chapter 9). This guidance document is also accompanied by two separately published appendices (link) that provide additional resources and guidance. **Appendix A** provides guidance and a decision tree to help managers select the appropriate CVA scope, example background materials and CVA worksheets, and resources for climate adaptation management. **Appendix B** provides a brief history of CVAs that have been conducted by ONMS in the past as well as an example of how a CVA can fit into the ONMS planning process. Further, this document is part of a larger MPA Climate Vulnerability Assessment Toolkit, a living resource that provides additional tools and resources to aid sanctuary and other marine protected area managers as they design and conduct a CVA.

Through this guidance document, national marine sanctuary and other marine protected area managers will obtain the knowledge and tools necessary to scope, design, and conduct a CVA that informs the intentional management of the resources under their stewardship in a changing climate.

Chapter 2:
Understanding Vulnerability

In order to make informed management decisions in a changing climate, protected area managers must first understand their resources' vulnerability to future environmental conditions. Whether a CVA is assessing a living resource, heritage or cultural resource, ecosystem service, or even a human community, it is necessary to understand the components of vulnerability to ensure shared understanding among CVA participants, and the accurate assessment of these variables.

Climate vulnerability is the measure of a resource's (e.g., species, habitat, ecosystem service, heritage resource, or community) susceptibility to one or more climate change and non-climate hazards. *Climate vulnerability* is a function of the *adaptive capacity* of the resource being evaluated and the *potential impact* of climate change on that resource. Further, the *potential impact* of climate change on the resource of concern is a function of the *exposure* and *sensitivity* of that resource to climate hazards (Figure 1). Each of these components of vulnerability are explored in greater detail below.

2.1 Exposure

For the purposes of a CVA, *exposure* is a measure of how much change in climate or other environmental hazards, including changes in the likelihood of experiencing extreme events, a resource or community is likely to experience over the assessed timeframe. For example, a measure of exposure may be the increase in average temperatures a resource is likely to experience by a given year expressed as "a projected 4°C increase in average sea surface temperature by 2100." For an ecosystem service, like non-consumptive recreation, it is viewed through the lens of the service being assessed. For example, travel by small crafts is affected by wind speeds. A measure of *exposure* may thus take a form such as "a projected 30% increase in days with small craft warnings" where the change, in this case increased windiness, is viewed through the lens of the service being assessed.

Exposure is a critical piece of information in the assessment of a focal resource's vulnerability to a hazard, and requires prior knowledge of how environmental conditions are projected to change over the time period being assessed. Ensuring that all participants have the necessary information to assess exposure will often require first characterizing or describing projected change in the assessed area. This can take many forms, from a literature review, to expert elicitation/opinion, to climatological modeling. A more detailed description of this and other necessary pre-CVA activities is available in chapters 4, 5, and 6.

2.2 Sensitivity

For the purposes of a CVA, *sensitivity* is a measure of whether and how a resource or community is likely to be affected by a given change in climate or another environmental hazard. For example, a measure of sensitivity may be a threshold at which a resource's exposure to high temperatures (a hazard) has an effect expressed as "corals in the area of concern bleach when temperatures exceed 2°C above local average highs." Alternatively, sensitivity may take the form of a rate of impact on a resource or service. For example, a rate measure of sensitivity could be that “catch of culturally important salmon decreases by 5% for every two inches of rainfall below normal variability.”

Information on a resource’s sensitivity can be gathered in advance of the assessment (see Chapter 4). However, sensitivity of resources may be difficult to assess quantitatively for several reasons including: unique circumstances or conditions of the specific resource, such as the depth of a historic shipwreck; difficult to quantify or highly variable, such as the stress experienced by an organism; or simply unknown. In such cases qualitative assessments may be conducted and expert opinion is often vital to determining a resource’s sensitivity.

Together, the sensitivity of a resource to a hazard and its exposure to that hazard produce the *potential impact* that resource is likely to experience (Figure 1). The potential impact could be positive, negative, or neutral from the perspective of the resource, and is a critical measure of a resource’s vulnerability to a hazard. As potential impact is a function of a resource’s sensitivity and exposure, it is generally not assessed independently, but rather by assessing resource exposure and sensitivity as an intermediate step to assessing vulnerability (see Chapter 6.4). Nevertheless, understanding this measure, and its interaction with a resource’s adaptive capacity, is critical to the successful completion of a CVA.

2.3 Adaptive Capacity

For the purposes of a CVA, *adaptive capacity* is a measure of the ability of a resource or community to adapt to the effects or impacts of an environmental change or hazard. Adaptive capacity can manifest in a number of ways from a resource’s ability to recover from an exposure it is sensitive to, like a coral recovering from warming-induced bleaching or a community creating a fund to pay for repair after coastal storms, to the ability to avoid exposure all together, such as a species moving northward in response to warming. It could also encompass strategies to lessen the effect of an exposure, such as a fishing community switching to species that are less impacted, or even the ability of a species to rapidly acclimatize or evolve to changing conditions, such as through phenotypic plasticity or connections to a genetically diverse metapopulation. These are all examples of “intrinsic” adaptive capacity. Some CVAs extend the assessment of adaptive capacity beyond that of the resource or community being assessed to that of the management agency, such as the capacity of an MPA to adjust its management authorities (see Chapter 6.5). This is sometimes referred to as “extrinsic” adaptive capacity. Another way to think of adaptive capacity is that it determines if, and to what extent, a potential impact on a resource becomes an actual impact, thus determining the resource’s vulnerability (Figure 1).

Not all resources have adaptive capacity, as is the case with tangible heritage resources such as shipwrecks, aids to navigation, maritime infrastructure, and submerged archaeological sites. These non-renewable resources often retain a high degree of significance based on their historical association with events, individuals, distinctive characteristics of a construction method or period, or their ability to yield information on the past. As this historical association is reliant on integrity of location, design, setting, materials, workmanship, feeling, and association, enhancing or adding site features to create adaptive capacity may, in turn, reduce resource integrity and significance. Thus, *in the case of tangible heritage, adaptive capacity is* *not assessed*. In such a case, the vulnerability of the resource is the same as the potential impact that resource is likely to experience.

Similar to sensitivity, determining the adaptive capacity of a particular resource or community being assessed will often require expert elicitation/opinion. While some information may be found in the scientific literature, the extent to which a resource in the particular area being assessed will be able to adapt to any given environmental change is often a complex calculation that is best determined qualitatively by a group of experts. For this reason, adaptive capacity is most often determined via elicitation/opinion through conversations during a CVA workshop (see Chapters 6 and 6.5).

For biological resources (species, habitats, etc.), adaptive capacity can sometimes be confounded with sensitivity. This is because the same trait that may make a resource highly sensitive, may also give it low adaptive capacity and vice-versa. For example, if a species has a wide thermal tolerance, it could be seen as having both low sensitivity and high adaptive capacity to changing temperatures. For this reason, some CVAs that assess only biological resources will not assess adaptive capacity directly, but rather incorporate it as a function of sensitivity (e.g., Farr et al. 2021). While this can be an option, this guidance document strongly cautions against this approach, particularly when conducting a CVA in order to inform management strategies. *Assessing adaptive capacity independently from sensitivity allows for a more complete understanding of the variables impacting a resource's vulnerability*, thus providing greater clarity and guidance of management levers. Adaptive capacity can also include actions that are independent of the resource being assessed (extrinsic adaptive capacity) which would not be included in an assessment of sensitivity, such as the ability of the management agency to quickly take management action. Thus, the assessment of adaptive capacity independent of sensitivity is often warranted (for greater discussion see Chapter 6.5).

2.4 Vulnerability

A resource's exposure, sensitivity, and adaptive capacity interact to determine the *vulnerability* of the resource being assessed (Figure 1). While the technical details of this assessment will be discussed in chapter 6, some qualitative examples of this process are described in Box 2.

Box 2: Qualitative examples of the components of vulnerability

Biological

A species of crab experiences decreased reproductive success under conditions that are more acidic than it currently experiences, making it *sensitive* to ocean acidification. Further, the level of ocean acidification expected to occur in the area of concern over the next century will result in the crab being *exposed* to conditions that are much more acidic than what it currently experiences, exceeding its tolerance threshold and creating a *potential impact* of ocean acidification on the crab. The crab has the ability to move to nearby areas that are not expected to experience increased acidity, so the crab has high *adaptive capacity* to this change. Thus, this crab is unlikely to be highly vulnerable to acidification. However, this example highlights the importance of context in assessing vulnerability. If the area to which the crab can move is outside of the area of concern for the assessment (e.g., out of a protected area), the crab could still be considered vulnerable within the context of the assessment for that area.

Heritage

An important archaeological site could be damaged if water levels rise more than three feet, making it *sensitive* to sea level rise. Sea level rise in the region is expected to rise between one and two feet over the next century, meaning that the site likely has low *exposure* to sea level rise. While the low exposure means that the site is likely not highly vulnerable to sea level rise, its high sensitivity and lack of adaptive capacity may cause CVA participants to avoid assigning low vulnerability, especially if sea level rise projections are uncertain. Determining levels of vulnerability is discussed in greater depth in chapter 6.6. This example highlights how the ability of managers to react to changes, in this case as any action could alter the site in such a way that reduces its integrity and significance (see Chapter 2.3), can play an important role in a resource's adaptive capacity and ultimate vulnerability.

Community/ecosystem service

A coastal community depends on its local recreational sailing fleet to provide tourism income. When sustained winds are greater than 35 mph, the amateur sailors who make up the bulk of tourists in this community cannot sail. Thus, the community is *sensitive* to changing wind patterns. The community also has high *exposure* to changing wind patterns as days where sustained winds exceed 35 mph are expected to increase by 20% in the next 25 years. In anticipation of changing winds, some tourism operators have begun transitioning to scuba and snorkel tourism, giving them some measure of *adaptive capacity* to changing wind patterns, while others are unable to afford the cost of the transition and thus have low *adaptive capacity* to changing wind patterns. This example highlights how the ultimate designation of sensitivity, exposure, and adaptive capacity are often complex and may require extensive discussion during a vulnerability assessment, even among experts.

Chapter 3: Selecting the CVA Scope

CVAs can range widely, from the discussion of a single resource among a few managers to the quantitative assessment of a range of ecosystems across a seascape. This guidance document covers two scopes that have been successfully implemented by national marine sanctuaries and other marine protected areas: “Limited” and “Extensive.” These two scopes of CVA use the same fundamental approach and components, but differ in the depth of analysis. *Neither scope is necessarily “better” than the other*. Instead, the scope should be determined through considerations such as the number of resources to be assessed, the diversity of resources to be assessed, the number and diversity of hazards of concern, the scale (both area and time) to be assessed, and the level of expertise that is accessible (both internal and external to the MPA). Appendix A provides a decision framework to help managers make an informed decision about which scope of assessment to undertake, as well as additional resources related to each scope.

3.1 Extensive Scope CVA

An *extensive CVA*, such as that conducted by Greater Farallones National Marine Sanctuary (GFNMS; Hutto et al. 2015), allows participants ample time and information to assess the vulnerability of a broad range of resources to a number of climate and non-climate hazards. An extensive CVA will often assess the vulnerability of a broad range of resources such as multiple habitat types, multiple focal species, and multiple ecosystem services. For example, the GFNMS CVA assessed eight habitat types including kelp forest and estuaries, 31 focal species including pacific krill and California mussel, and five ecosystem services such as food production and carbon storage. Further, an extensive CVA will often assess the vulnerability of these resources to multiple climate and non-climate hazards. The GFNMS CVA, for example, explored 16 climate-related hazards, such as pH and sea level rise, as well as 16 non-climate hazards like roads/armoring and land use change. The process of an extensive CVA allows participants to add and consider additional climate and non-climate hazards during the assessment. Such additions can help participants assess hazards that may be unique to particular resources. Greater detail on how resources and hazards are assessed during an extensive CVA is explored in more detail in chapter 6 with particular focus in chapters 6.3.1 and 6.5.1. While all CVAs should incorporate partners other than the MPA itself, the breadth and depth of an extensive CVA makes involving partners particularly important to its success.

3.2 Limited Scope CVA

A *limited CVA*, such as that conducted by Gray’s Reef National Marine Sanctuary (GRNMS; Shein et al. 2019), allows managers to assess the vulnerability of a limited number of resources to a focused selection of climate and non-climate hazards in a relatively short period of time. For example, the GRNMS CVA assessed the vulnerability of nine species found within the sanctuary during a two-day workshop. Two additional species were assessed by experts independently after the workshop. Each species was assessed for its vulnerability to no more than three climate and three non-climate hazards. The climate and non-climate hazards assessed differed between species and were chosen through informal discussions as the hazards most likely to affect the individual species being assessed. The process of a limited CVA does not allow participants to consider hazards for which information has not been provided, but does allow them to leverage their expertise to provide an assessment of vulnerability in a relatively short amount of time. Greater detail on how resources and hazards are assessed during a limited CVA is explored in more detail in chapter 6 with particular focus in chapters 6.3.2 and 6.5.2.

3.3 Comparing Scopes

Both scopes of CVA described above produce high-quality information about the vulnerability of resources that is valuable to managers and climate adaptation planning. Where they differ is in the amount of information produced, as well as the level of resources and capacity required. As such, when choosing the scope of CVA to conduct, it is important that managers balance these considerations. *The scope that is "right" for a particular MPA will depend on a range of variables* including the diversity of resources of concern to the site (i.e., habitats, species, heritage resources, ecosystem services), the number and diversity of hazards that need to be assessed, the capacity and resources of the site, and even the size of the MPA. In the above examples, GFNMS is a much larger, more complex site, composed of many different habitat types and impacted by a vast array of both non-climate and climate change hazards, whereas GRNMS is a small, discrete site composed of one primary habitat type and largely removed from many non-climate hazards. For GFNMS, only an extensive CVA was appropriate, whereas the limited CVA provided sufficient information for GRNMS. For many MPAs, either scope will provide sufficient information and the decision will come down to considerations of capacity, resources, and the level/amount of information desired. However, given that a limited CVA allows for the inclusion of only three climate and three non-climate hazards per focal resource, it may not be appropriate for sites where a large number or diversity of hazards are important or where determining the relative importance of many hazards is a primary goal of the CVA. Appendix A provides a decision tree to help managers decide on the scope of CVA to conduct, but *the decision will ultimately be one that is informed by the unique conditions of the MPA being assessed.*

Both extensive and limited scope CVAs allow for the assessment of a broad range of resource and hazard types using a basic, shared framework. The flexibility and relative ease of use of these frameworks makes them broadly applicable and appropriate for most MPA climate planning activities. However, there are instances where neither of these frameworks will produce the type of information desired by managers. This is most often the case when assessing highly specialized resources and/or when quantitative information is desired. In such instances, a more technical (e.g., Metzger et al. 2006) or specialized tool (e.g., Dudley et al. 2021) may need to be sought out.

Chapter 4: Selecting Focal Resources, Timescales, and Hazards

Regardless of the scope chosen, no CVA can assess the vulnerability of all resources found in an MPA to all hazards at all timescales. The resources, timescales, and hazards to examine during a CVA is a critical decision that will guide and frame the rest of the assessment. In most cases, an initial decision will be made prior to deciding the scope of the CVA, as the number and types of resources, timescales, and hazards to be assessed will inform the scope best suited to the assessment. However, refining a final list of resources and hazards to be assessed can only occur after a scope has been chosen. Further, the final resources, hazards, and timescale to assess should be vetted with subject matter experts and CVA participants prior to the assessment. As such, the process of choosing resources, timescales, and hazards to be assessed is iterative and interwoven with the process of choosing both the scope of the CVA (see Chapter 3) and CVA participants (see Chapter 5). This chapter covers processes and considerations when choosing the resources, timescales, and hazards to assess. This process must occur in conjunction with other pre-assessment planning decisions and is necessarily flexible to changes and other considerations that arise throughout the CVA process. Thus, while choosing resources, timescales, and hazards to assess is a critical and influential step of planning a CVA, it is also flexible and likely to be altered throughout the process.

4.1 Selecting Resources to Assess

The selection of the resources to assess during a CVA is guided by management questions and local context. For the purposes of a CVA, a "*resource*" can be many different things including species, functional groups, habitats, ecosystems, ecosystem services, tangible cultural and heritage resources, intangible cultural practices and ways of knowing, cultural landscapes, and just about anything else that an MPA manages or protects. Given this variety, this document defines a *resource* as any of those things listed above that are managed, protected by, or found in an MPA, as well as ecosystem services provided by the MPA to communities or stakeholders.

Given this broad definition, the initial filtering of resources to assess during a CVA, hereafter referred to as "*focal resources*", is often conducted by managers. Further, as the focal resources will inform the scope of the CVA (see Chapter 3), this initial step is among the first conducted during the CVA planning process. This initial filtering should be rooted in the mission of the MPA and critical management considerations, such as: the resources under direct management jurisdiction, the number and diversity of natural or heritage resources found in the MPA, the communities and stakeholders that depend on the MPA, and whether there are any critical management challenges facing the MPA. For example, a small MPA that protects only one habitat (e.g., live bottom reef) would likely choose a number of focal species, such as those which are endangered or ecologically, commercially, and/or culturally important found in that habitat to assess. As the assessment of these few critical species would serve to address the MPA's management questions, a limited scope CVA would likely be appropriate. In contrast, a large site that protects multiple species, cultural and heritage resources, and ecosystems (e.g., intertidal out to deep ocean canyons) might choose to assess multiple types and levels of resources. This could include key habitats or ecosystems, inclusive of the species found within, as well as the assessment of resources at multiple scales, such as habitats and critical species, or types, such as natural and heritage. The diversity of resource types and scales in such an assessment would likely necessitate an extensive CVA. Managers are the most well-positioned to make such initial broad-stroke decisions on the types of resources to assess prior to defining the CVA scope. Once these initial decisions are made, they will guide the rest of the process of both resource selection and the CVA more broadly.

After making the initial determination of the potential focal resources, it is advisable that managers vet their choices with subject matter experts and stakeholder/community groups. This is particularly important if managers identify a large number of potential focal resources, as subject matter experts can provide guidance on reducing the list to a manageable level. The process for selecting subject matter experts is explained in more detail in chapter 5, but local experts with familiarity with the MPA are often best suited to this task.

Almost all MPAs have a near limitless number of resources that could be assessed. Thus, *the final selection of focal resources is a balance* of the mission of the MPA and the value of the resources to the community, the perceived vulnerability of resources, the authority of the MPA, feasibility, the scale of the MPA and resources, and the capacity of managers and experts (Figure 2). Each of these factors is described in more detail below:

Greater Farallones and Cordell Bank National Marine Sanctuary Focal Species Evaluation

Instructions: For each question, answer yes or no. Rank species based on final point value

Resource:

Criteria	Yes/No	Points
Is the resource federally listed as threatened, endangered, proposed or candidate, or is the resource a species of conservation concern?		2
Is the species considered to be: a keystone species, a key species, ecologically foundational, a strong indicator, or an umbrella species?		2
Does the species have available data and information upon which to base the vulnerability assessment?		2
Does the species have socio-economic significance?		1
Is the species considered to be, or used as, a surrogate for a larger group of species?		1
Is the resource widely represented across the California Current (0 points) or is it more narrowly present in the study region (1 point)?		1
Is the species in the Indicator Monitoring Inventory and Plan?		1
Does the resource have substantial management implications?		2
	Total:	

Figure 2. Example of a worksheet used by Greater Farallones and Cordell Bank National Marine Sanctuaries to prioritize species to be included in an extensive CVA. Image: NOAA

MPA Mission/Value– Are there resources that are of particular value to the mission of the MPA or otherwise important? Resources that are critical to the mission of the MPA, or are culturally, ecologically, or economically important are good candidates for prioritization as their vulnerability is likely to have an outsized impact. Among other considerations, this can include resources such as keystone, indicator, or umbrella species; resources that are culturally or socio-economically important; resources that can be used as a surrogate or are representative of a larger group of resources; and resources that are unique, or nearly unique, to the area being assessed.

Perceived Vulnerability – Are there resources that are likely to be particularly vulnerable? Even prior to a formal CVA, managers, communities, and subject matter experts often have an initial idea of some resources that are likely to be particularly vulnerable to climate change. Such resources are often those that are already displaying vulnerability (e.g., coral bleaching) or located in areas where change is expected to be high (e.g., a midden found on a low-lying beach). These resources are often those where adaptation actions are most critical and can thus greatly benefit from the CVA process.

Authority – Are there resources managed by the MPA that are not otherwise managed by or under other agencies or authorities? Prioritizing the assessment of resources for which the site is solely responsible can be a good use of limited resources. For example, national marine sanctuaries contain numerous fish species, but their management often falls to other agencies such as NOAA Fisheries or the states. While it can still be important to choose fish species as focal resources, which sanctuaries often do during a CVA, if resources are very limited it may be preferential to prioritize the assessment of a resource for which the sanctuary has sole management authority, such as a shipwreck. Further, rather than excluding resources for which the MPA does not exercise direct management authority, if the capacity is available, managers should instead invite the management entities responsible for those resources to be a part of the CVA (see Chapter 5).

Feasibility – Does the information to assess the proposed resource exist? A resource for which little is known, such as a little-studied species, may not have sufficient information available to assess its vulnerability. This can often be addressed by increasing the scale at which the resource is being assessed, such as assessing deep water corals as a group rather than an individual species or coastal archaeological sites on the whole rather than a specific midden. In some cases, even if very little information exists, the critical importance of the resource may still make it important to assess, even if it results in high uncertainties in the assessment.

Scale – At what scale do the resources need to be assessed (e.g., species vs ecosystem, cultural landscape vs. individual shipwreck)? In order to gain the information required for successful management action, is it sufficient to assess a resource as part of a larger grouping, reducing the overall number of resources to be assessed, or will it need to be assessed individually? This consideration of scale is often critical to determining the appropriate CVA scope. Further, the scale at which resources need to be assessed can sometimes be tied directly to the size of the MPA and the diversity of resources found within it. This interaction between the scale of the focal resources, the scope of the CVA, and the size of and resources protected by an MPA is explored in greater depth in Box 3.

Capacity – How many resources can be assessed given the scope of the CVA, time, funding, and other capacity considerations? Ultimately, a decision on the focal resources that are assessed must be constrained by considerations of the capacity to assess those resources. As a quality assessment is critical to the development of successful adaptation and management actions, high quality assessments of a few resources are often better than low quality assessments of multiple resources. While high quality CVAs can be conducted even with low capacity, managers must be realistic about these constraints in order to maximize the efficacy of the CVA.

Box 3: The interaction of MPA scale and assessment scope in resource selection

A critical way in which the selection of focal resources interacts with choosing the appropriate CVA scope centers around the appropriate scale at which to assess resources. The scale at which resources need to be assessed can be very helpful in informing the appropriate scope of the CVA and vice-versa.

Perhaps unsurprisingly, the appropriate scope at which to assess resources is often tied to the size and management mission of the MPA for which the assessment is being conducted. Larger MPAs often contain a variety of habitats and ecosystems that themselves contain a broad diversity of species, provide a wealth of ecosystem services, and may contain a variety of heritage resources. If such an MPA wishes to assess vulnerability over this breadth of resources, they will need to consider a breadth of resource scales. For example, Olympic Coast National Marine Sanctuary (OCNMS) assessed the vulnerability of the kelp forests (a habitat), copepods (a group of species found within kelp forests), red sea urchins (a species found within kelp forests), and carbon storage and sequestration (an ecosystem service provided by kelp forests). Similarly, the CVA assessed the vulnerability of pelagic open ocean (a habitat), copepods (a group of species found in the pelagic habitat), Coho salmon (a species found in the pelagic habitat), and subsistence harvest (an ecosystem service provided by the pelagic habitat). The CVA also assessed numerous other habitats, species, groups of species, and ecosystem services, many of which are found in or provided by multiple habitats. Given the diversity of resources and scales to be assessed, OCNMS conducted an extensive CVA in order to ensure the multiple scales and interactions among focal resources could be thoroughly assessed. This example demonstrates how the selection of resources that span a diversity of scales, some of which are inclusive of other focal resources (e.g., kelp forests contain red sea urchins), can be informed by the size and mission of the MPA and may lead to preferentially selecting one scope of CVA over another.

In contrast to large MPAs, smaller MPAs, or those with a very narrow management focus, may find that assessing resources at a limited number of scales is most appropriate. For example, Gray's Reef National Marine Sanctuary (GRNMS) protects a single live bottom reef. As this site protects only a single habitat type, managers chose to assess the vulnerability of numerous species within that habitat. As all of the resources assessed were at the same scale of "species", the "nesting" of resources within other resources was not a factor in this CVA, reducing complexity. The relatively small size of the site also allowed managers to assess a relatively small number of resources (11 species) while still covering the breadth of resources of concern to climate-informed management. This combination of a relatively low complexity of scales and a small number of focal resources facilitated the success of a limited scope CVA. This combination of a low complexity of scales and a small number of focal resources is often also found in CVAs conducted by MPAs with limited management authorities. For example, Thunder Bay National Marine Sanctuary is geographically large (4,300 square miles), but has management authority only over the shipwrecks within its borders, resulting in the potential for the assessment of resources of similar scales.

The above examples serve to demonstrate how the scale and diversity of resources, MPA size, and MPA authorities can interact to inform focal resource and CVA scope selection. However, these examples should not be taken to suggest that a large MPA should always conduct an extensive CVA and a small MPA should always conduct a limited CVA. Either scope can be used to assess the vulnerability of resources in MPAs of any size, but the *scale* and *diversity* of resources that need to be assessed to adequately address management questions may make one type of CVA scope more attractive and likely to succeed than another.

4.2 Timescales

Assessing the vulnerability of focal resources over a defined timescale allows for a more focused CVA. It is most common to assess the vulnerability of focal resources over the 10 (near-term), 50 (mid-term), and 100 (long-term) years following the assessment. The timescale chosen should be a balance of management planning considerations (i.e., on what timescale are decisions made?) and the timescales relevant to the vulnerability of focal resources. The availability of information about hazards and vulnerability of focal resources at particular timescales can also affect the timescale chosen (e.g., do climate projections exist for the MPA at the preferred timescale?), but if such data gaps exists, they can often be overcome through expert opinion.

It is recommended that a CVA consider one timescale throughout the process as assessing vulnerability across multiple timescales can drastically increase the effort and resources required. If time and capacity are available, and it is deemed necessary, a CVA can assess vulnerability at multiple timescales (e.g., mid- and long-term). However, with very few exceptions, all focal resources should be assessed for all timescales that are included in order to allow for comparisons of vulnerability across resources and inform prioritization of adaptation actions (see Chapter 7).

An alternative to selecting a single timescale to assess for all resources is to instead consider resource thresholds or loss dates after which adaptation may no longer be possible. In such a scenario, a resource is not assessed for its vulnerability within a particular timescale, but rather its vulnerability to loss over an undefined time. This strategy is common when considering heritage resources such as shipwrecks and archaeological sites that have no intrinsic adaptive capacity. However, this guidance document cautions against this approach for non-heritage resources, and suggests caution even for heritage resources, as the results of such a CVA can prove complicated to compare across resources, making it more difficult to prioritize adaptation and management actions.

4.3 Selecting Hazards to Consider

The selection of hazards to consider in a CVA is informed by a combination of the focal resources, the context of the MPA (geographical, ecological, cultural, etc.), and the information available. The scope of a CVA also plays an important role in the hazards assessed. A limited CVA is often restricted to a list of pre-determined hazards while the flexibility of an extensive CVA allows for the consideration of a nearly unlimited number of hazards. The hazards chosen can also inform the CVA scope as if it is desirable to assess more than three climate or non-climate hazards per focal resource, a limited CVA is not appropriate (see Chapter 3). Regardless of the CVA scope, prior to the CVA it is advisable to determine a list of climate and non-climate hazards common to the MPA. In an extensive CVA, the vulnerability of each focal resource will generally be assessed for every relevant climate and non-climate hazard, with the option for additional hazards to be added to the assessment when experts deem it appropriate. During a limited CVA, resources are assessed for a set number of climate and non-climate hazards, up to three of each, that are either chosen during the assessment from a pre-developed list, or prior to the assessment by those organizing the CVA (see Chapters 3.2 and 6.3). All resources can be assessed for the same hazards, or each could be assessed for different hazards, a decision that should be made by MPA managers prior to the assessment.

The initial list of hazards to be considered should be created by MPA managers with the input of select subject matter experts. The climate change hazards to consider are often similar across MPAs and include large-scale factors such as ocean warming, ocean acidification, and sea level rise. It is also important to include climate change-related hazards that may be locally or regionally specific, such as changes to upwelling on the US west coast, or of importance to a focal resource of particular concern, such as changes in turbidity that may be a concern to sponges and corals. It is recommended to *select climate hazards that act on different spatial scales* (e.g., storms severity vs warming) *or act by different mechanisms* (e.g., are not inherently interrelated, such as ocean acidification vs. sea level rise) as these differences can help to reveal alternative adaptation strategies. These considerations are of particular importance for a limited CVA where the assessment is constrained by the list of hazards presented.

While some non-climate hazards likely to be considered in a CVA are common globally, many can be highly specific to the local or regional context of the MPA being assessed. For example, fishing pressure is a non-climate hazard experienced in many MPAs while discharge of cooling water may only be of relevance to MPAs adjacent to power plants. As such, the non-climate hazards selected should be those that are of greatest concern to the focal resources, the local context of the MPA, or of particular interest and concern to local communities and stakeholders. Similar to climate hazards, it can often be useful to select non-climate hazards that act on different spatial scales (e.g., pollution vs boat groundings) or act by different mechanisms (e.g., are not inherently interrelated, such as noise vs. invasive species) as such differences can help to reveal alternative adaptation strategies. These considerations are of particular importance for a limited CVA where the assessment is constrained by the list of hazards presented. Some CVAs do not include considerations of non-climate hazards, preferring to assess resource vulnerability only to those hazards presented by a changing climate. However, this guidance strongly encourages including non-climate hazards in a CVA as assessing the vulnerability of resources to these hazards allows managers to explore interactions between climate and non-climate hazards, as well as to identify where management actions can be taken. As MPAs often have more power to directly mitigate non-climate hazards compared to climate hazards, the management actions identified to address resource vulnerability to non-climate hazards are often among the most readily actionable.

In addition to the considerations described above, the selection of hazards is often informed by the availability of applicable information about the hazards being considered for inclusion. A hazard for which there is little or no information at the relevant timescale or geographic focus may not be a good candidate for inclusion, particularly for a limited CVA. However, the inclusion of a hazard that has little information available may still be warranted if it is likely to be particularly impactful (e.g., temperature change is particularly impactful on corals). In such an instance, the CVA may need to rely on expert opinion rather than published information. Qualitative examples of the hazard selection process are described in Box 4.

Box 4: Qualitative example of hazard selection

Managers of an MPA are selecting climate hazards to include in their CVA, which will assess the vulnerability of focal resources in the mid-term (next 50 years). In pre-CVA planning discussions, managers on the CVA planning committee have chosen to consider sea surface temperature, pH, aragonite saturation state, and storm frequency and strength in the assessment, among others. A review of the scientific and gray literature conducted by a graduate student showed that there is ample information both about these factors in the region of the MPA and how they will change over the next 50 years. Further, there has been research exploring the effects of these factors on many of the focal resources chosen for the CVA. The managers also chose to include changes to precipitation as a hazard to be assessed. While there is little information about how this hazard will change in the region of their MPA, a focal resource of particular concern has been shown to be highly sensitive to changes in precipitation, and thus its inclusion is warranted. After discussing the initial list of hazards with subject matter experts, the managers also included changes to wave strength, a hazard that is locally significant.

The managers also selected a number of non-climate hazards to consider including pollution, commercial fishing, recreational fishing, and ocean noise. Information about these non-climate hazards in the sanctuary exists, but is less robust than the information relating to climate hazards. As such, the managers plan to rely heavily on expert opinion when assessing the vulnerability of focal resources to these hazards, a common practice during a CVA. After discussing the initial list of hazards with subject matter experts, the managers also included interactions with an invasive species that was newly discovered just outside of the MPA and is expected to benefit from warming waters.

This example demonstrates a number of reasons and methods for determining hazards for inclusion. While the full list to be examined in a CVA will often be much longer, the hazards explored here act on a range of spatial scales and mechanisms, demonstrating a best practice for the selection of hazards. Further, it is apparent that some of the climate and non-climate hazards may interact (e.g., pollution and changing precipitation, invasive species and sea surface temperature). This is common and allows for explorations of how these interactions affect focal resource vulnerability.

4.4 Pre-CVA Materials on Resources, Timescales, and Hazards

Prior to the CVA, it is important to assemble information about the selected focal resources, hazards, and timescale to ensure that all participants have the information necessary to conduct a CVA. This information can take many forms, but will generally be assembled into some form of handout, report, and/or presentation for CVA participants. Regardless of its final form, the information presented to participants should, at a minimum, include a summary of the current and projected state of the hazards to be considered in the area over the timescale being assessed. It will often also include some information about the observed or projected impacts of hazards on focal resources.

Gathering and assembling this information will often fall to the managers and other staff who are responsible for planning, organizing, and facilitating the assessment. This can also be a good step to engage subject matter experts ahead of the assessment to ensure that the information being gathered is up to date and accurate. In some instances, teams of subject matter experts may even be assembled to compile and present this information. However, managers should consider the capacity of subject matter experts, especially if they are also participating in the assessment, before assigning the task of compiling information.

The task of gathering the necessary information often takes the form of a literature review or "desktop analysis" of the scientific and gray literature. Other planning or assessment activities conducted for the MPA can also be a valuable source of information. For example, national marine sanctuaries assess the status and trends of resources within the sanctuary about every ten years through the production of condition reports. Condition reports and similar resource assessments can provide a wealth of information to inform a CVA. Managers should also consider how to engage with communities and stakeholders to gather relevant information that cannot be found through these methods. Given these considerations, the final product of this review often takes the form of a report that can be presented to subject matter experts ahead of, and used as a resource during, the CVA. Depending on the capacity and expertise of those conducting the review, and the needs of managers, the final product of the review can take many forms from a short report, such as the 4-page table produced for the National Marine Sanctuary of American Samoa limited scope CVA, to a multi-chapter extensive review of the scientific literature (See Appendix A). Regardless of its final form, this information should be presented to participants ahead of the CVA and, if it takes the form of a large report, distilled into easily digestible information that can be referenced throughout the assessment. This distillation into a digestible product is of particular importance to a limited scope CVA as the limited time for the assessment requires that participants are able to quickly access relevant information.

Chapter 5: Selecting and Inviting CVA Participants

Successfully conducting a CVA requires MPA managers to engage subject matter experts, stakeholders, and other relevant community members throughout the process. This not only allows managers to leverage outside expertise to assess resource vulnerability, but also increases the diversity of viewpoints represented during the assessment and enhances buy-in for actions the sanctuary may choose to take as a result of the process. *A well-chosen group of CVA participants will introduce new perspectives, local and subject matter expertise, and challenge assumptions, leading to a more complete and more useful CVA*. This chapter will provide best practices and suggestions for selecting and reaching out to participants. Participants often largely include people familiar to managers like research partners, local subject matter experts, and members of an MPA's advisory body, such as a Sanctuary Advisory Council. However, the precise make-up of participants will be informed by the CVA scope, focal resources, hazards, and other unique aspects relevant to the MPA being assessed.

The participants that are invited to a CVA are those who can bring expertise on subjects of relevance. This includes subject matter experts on local climate impacts and focal resources, but may also include local experts on non-climate stressors, social science, Indigenous knowledge, and other topics of local or topical relevance. Determining the needed expertise is often as simple as exploring the list of hazards and focal resources to be assessed and ensuring that experts, particularly local experts if available, are identified for each topic. For resources that are of particular interest, it may be necessary to identify multiple participants with applicable expertise. Alternatively, there may be participants that can serve as the primary expert for multiple resources or hazards. It is also important to remember that a decision-making process should include those that are affected by the decision as well as those that affect the decision. Thus, in addition to participants with subject matter expertise on focal resources and hazards, it is also important to include representatives of local stakeholder groups, communities, and management partners. Beyond increasing buy-in to the climate-planning process, such participants can bring a wealth of important perspectives to the CVA above and beyond any hazard or resource expertise they may be able to provide. Further, the management goals and objectives of the MPA can help inform and drive the selection of participants. For example, the National Marine Sanctuaries Act[2] notes that sanctuaries should be designated to protect "areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational or esthetic qualities." As such, inviting experts that have knowledge of each of these aspects which is relevant to the sanctuary being assessed is likely advisable for any national marine sanctuary conducting a CVA. When reaching out to subject matter experts, communities, and stakeholders, managers should consider ways to facilitate diversity and reduce barriers for participation. While beyond the scope of this guidance, there are numerous resources that can

[2] 16 U.S.C. §§ 1431 et seq

help managers understand and implement best practices and guidance for equitable community co-development.[3]

The initial identification of participants is conducted by the managers and staff tasked with planning the CVA. While participants will likely include some MPA staff, external participants will almost always be needed to ensure the necessary suite of subject matter expertise is represented. Even when internal expertise exists for a particular topic, it is advisable to seek out external expertise to provide additional perspectives. Managers often find it easier to identify potential participants than they might first expect. Management partners, researchers, academics, and local stakeholder and community groups that regularly work with and in the MPA are often ideal places to begin identifying participants. Advisory groups, such as Sanctuary Advisory Councils, can also offer both a wealth of participants and connections. People who have participated in other planning and assessment exercises, such as condition reports or management plans, are also ideal candidates for a CVA.

Managers will generally know the best way to contact and invite potential participants, which can be as simple as an email or as formal as an official request. It is important to be upfront with participants by describing the request and the expected workload as soon as possible. Managers commonly hold a meeting, often virtually, with potential participants soon after sending an invitation and well before any planned CVA activities. This meeting should cover topics such as what a CVA is and why it is being conducted, the expected workload and activities, and the focal resources and hazards to be assessed. Beyond ensuring that participants are fully aware of the process and expectations, this meeting serves as an opportunity to vet focal resources and hazards. Attendees at this meeting can help to refine these lists and identify additional expertise or participants that should be included in the CVA.

The process of selecting CVA participants is one of the most straightforward and intuitive tasks in planning and conducting a CVA. However, it is also a step that requires particular attention as the information produced by a CVA can only be as good as the perspectives and expertise of its participants. Managers may also worry that they are inviting too many or too few participants. There is no set formula for the number of participants, but it is advisable to *balance needed representation and expertise with a small enough group to have productive conversations*. Even with these considerations, ensuring the necessary expertise is represented can cause the participant list to quickly become large. For example, the extensive scope CVA conducted by Olympic Coast National Marine Sanctuary included 30 participants. In contrast, the Gray's Reef National Marine Sanctuary limited scope CVA included 17 participants. Separating participants into breakout groups based on expertise and topic (see Chapter 6.1) helps to balance these concerns by allowing for smaller, more focused groups that still have the necessary expertise represented. When in doubt, it is generally advisable to err on the side of inviting extra participants to ensure that the necessary expertise and representation are present. An example of the breadth of expertise that may be necessary is included in Box 5.

[3] Some resources to inform equitable community development: [US Department of the Interior Engagement Resources](); [International City/County Management Association: How to Facilitate Inclusive Community Outreach and Engagement]()

Box 5: Example of CVA Participants

Olympic Coast National Marine Sanctuary is a large MPA with a diversity of resources and partners. As such the site's extensive CVA included the assessment of 68 focal resources and many climate and non-climate hazards. To cover the expertise necessary to assess these resource and hazards, as well as the inclusion of local stakeholders, communities, tribal representatives, and other partners, the CVA involved 30 participants including:

- 7 site staff
- 3 oceanographers
- 2 coastal hazards specialists
- 2 kelp/algae specialists
- 1 social scientist
- 4 tribal staff
- 1 economist
- 2 invertebrate specialists
- 5 fish/fishery specialists (inclusive of the 4 tribal staff)
- 2 bird specialists
- 3 marine mammal specialists
- 2 CVA specialists/facilitators

Gray's Reef National Marine Sanctuary is a relatively small MPA that protects one live bottom reef habitat. As such, the site's limited CVA included the assessment of nine focal resources by 17 participants including:

- 4 site staff
- 2 national fishery/fish specialists
- 1 local ocean chemist
- 1 conservation specialist
- 2 local fishery/fish specialists
- 1 local invertebrate specialist
- 1 policy specialist
- 3 local ecologists
- 1 climatologist
- 1 CVA specialist/facilitator

Chapter 6: Conducting the Assessment

The heart of a vulnerability assessment is the CVA workshop. While the workshop will differ slightly depending on the scope of the CVA, the differences are in scale rather than content or structure: a workshop will be longer, contain more breakout groups, and go into greater depth of assessment for an extensive scope CVA as opposed to a limited scope CVA. During the workshop, participants will be presented with relevant hazard information and come together to assess the vulnerability of focal resources by working through a number of worksheets. This is often accomplished by separating participants into focused, facilitated breakout groups where they will assess the vulnerability of focal resources, or sets of resources, for which they have subject matter expertise, concern, or interest. Results of the breakout groups are then shared with the full group of participants to facilitate further discussion. This process is described in detail below.

A CVA workshop can be held in-person or virtually. While a virtual workshop can provide more flexibility in participation and scheduling, experience shows that in-person workshops generally allow for more focused engagement and enhanced discussion. As such, virtual workshops generally require a greater workload for facilitators to ensure that outcomes are achieved. Given these considerations, this guidance document suggests that workshops be held in-person when possible. However, if logistical or other constraints make an in-person workshop untenable, it is more than possible to conduct a successful virtual CVA workshop, as was done for the Olympic Coast National Marine Sanctuary CVA.

6.1 Forming Breakout Groups

Unless there are a small number of participants involved in the workshop, it is advisable to break participants into breakout groups (ideally of 5-8 participants) to conduct the assessment. A workshop generally consists of multiple breakout sessions (Figure 3) and participants are assigned to the appropriate breakouts in each session based on their expertise and interest. Employing breakout groups in this way ensures an efficient use of participant time while allowing them to interact with a diverse cadre of their fellow participants across multiple breakout sessions. Depending on the time available, the number of focal resources, and the diversity of expertise, breakout sessions can assess single resources, or groups of related resources. For example, in one breakout session, there may be three breakout groups assessing the vulnerability of kelp forests, beaches, and intertidal habitat, respectively. In the next session, there may be two breakout groups where one assesses the vulnerability of Coho salmon, rockfish, and halibut while the other assesses copepods, pteropods, and Dungeness crab. While each of the resources will be assessed with its own worksheet, assessing related or similar resources with the same breakout group can speed the assessment.

Climate Vulnerability Assessment Workshop Breakout Group Agenda

Day 1 – Breakout Sessions 2:00-5:00pm

2:00 Breakout Session 1 – Habitats, 2 groups

- Group 1: sandy seafloor, beaches, and rocky shore
- Group 2: seep-sea, pelagic, and kelp forest

2:45 Breakout Session 2 – Fish, 3 groups

- Group 1: Anadromous fishes (3 salmon spp. and eulachon)
- Group 2: Groundfish and flatfish (halibut, whiting, 3 rockfish spp.)
- Group 3: Forage fish (anchovy, herring, sandlance, surf smelt)

4:15 Breakout Session 3 – Marine Plants, 3 groups

- Group 1: Kelp (bull kelp and giant kelp)
- Group 2: Seagrasses (eelgrass and surfgrass)
- Group 3: HAB-forming phytoplankton (dinoflagellates and *pseudo-nitzchia*)

Figure 3. Portion of the agenda for the Olympic Coast National Marine Sanctuary CVA providing an example of how breakout group sessions can be organized. Image: NOAA.

Subject matter experts should be assigned to the breakouts covering the resources for which they have expertise. The organization of focal resources into breakout groups will often be informed by the subject matter expertise available. For example, if one person has subject matter expertise on black tipped reef sharks and coral reef habitats, these resources should not be assessed in separate breakout groups during the same session. While subject matter experts are important to consider in the formation of breakout groups, it is not necessary that every participant in a breakout group be an expert on the resource being assessed. Including non-subject matter experts in the assessment of a resource often results in improved outcomes as these participants will bring in outside perspectives and expertise, and often ask questions of the experts that force deeper thinking. As a result, the best way to assign participants to breakout groups is to first, create breakout groups by assigning specialized subject matter experts and then either assigning the remaining participants, or allowing them to select the breakout groups that most interest them (although some control may need to be expressed to maintain breakout groups of manageable size).

In addition to participants, each breakout group should have a dedicated facilitator and note taker. These can be the same person if capacity is limited, but it is preferable to have one person in each role. The facilitator will facilitate the breakout group by walking participants through the worksheets, answering questions, and ensuring that the assessment is completed correctly and in a timely fashion. Facilitators may need to be trained prior to the workshop, but this can often be accomplished with a relatively short training session (2-3 hours). Note takers are responsible for filling out the group worksheets and capturing conversation, areas of disagreement, and other relevant points of discussion that may not be captured in the worksheet but are relevant to the CVA report (see Chapter 8).

6.2 Providing Background Information

During the workshop, it is important to provide participants with background information on relevant hazards and their known impacts on focal resources. This information can and should be drawn from the review, and any resulting materials, conducted prior to the workshop (see Chapter 4.4). Information relevant to all focal resources, such as general trends and projections of climate hazards for the area being assessed, should be presented early in the workshop. This often takes the form of a short presentation to the full group of workshop participants. It is useful to ask a participant who is a subject matter expert on these hazards to give this presentation as it lends additional authority to the information presented. In addition to the presentation, it can also be useful to provide participants with a short one- to two-page document summarizing the trends and projections of major hazards which they can refer to throughout the workshop. If time is limited, as may be the case in a limited scope CVA, this short document can replace a presentation altogether, but this is not recommended. If participants are given a summary document in lieu of a presentation, time should still be set aside to allow participants to ask questions about the information presented to ensure there is no confusion prior to conducting assessments.

In addition to the hazard summary described above, any information relevant to the assessment of focal resources should be provided to participants prior to conducting the assessment of that resource. This includes information such as known effects of hazards on the resource, past resource trends in the area being assessed (e.g., condition report findings), information about hazards relevant to the resource that were not previously discussed, and any other information deemed relevant to the assessment of that resource. This information will often come to light in pre-workshop reviews and discussions with subject matter experts. It is best to share this resource-specific information immediately prior to conducting the assessment of that resource to ensure that all participants are on the same page. If conducting breakout groups, this information should be shared only in the relevant breakout to avoid confusion and save time. The need to share this information can also inform the formation of breakout groups (see Chapter 6.1) as it is advisable to only include one short presentation at the beginning of each breakout. For example, similar hazards may be of relevance to copepods, pteropods, and Dungeness crab, allowing all three of these resources to be assessed in the same breakout, while it is likely that black tipped reef shark and coral are sensitive to different hazards, suggesting that they would be most efficiently assessed in different breakout groups.

If not utilizing breakout groups, as can be the case in limited scope CVAs, resource-specific information can be presented to the full group of participants immediately prior to assessing each resource. If time is limited, this information can be presented in an easily digestible handout that participants can reference during the assessment, but this strategy is not preferable. Further, the use of a handout rather than a presentation to present resource-specific information is strongly discouraged for extensive scope CVAs. The number of resources and diversity of hazards assessed in extensive CVAs make such handouts unwieldy while presentations immediately prior to assessment allow participants to focus on the resource at hand, leading to a more productive and informed discussion.

Once participants have been provided with information relevant to focal resources and hazards in the area being assessed, they are ready to begin the work of assessing vulnerability. For both extensive and limited scope CVAs, participants assess vulnerability by working through worksheets as a group. The worksheets differ between CVA types and example worksheets can be found in Appendix A. The worksheets can be modified to fit the needs of the assessment, although there is more flexibility to conduct this modification in an extensive CVA. Worksheets also differ slightly depending on the type of resource to be assessed (e.g., habitat vs. species), allowing the inclusion of factors that are only of relevance to that resource type. This guidance document provides examples and worksheets for assessing four distinct types of focal resources: species, habitats, ecosystem services, and heritage resources (inclusive of cultural resources).

At this point in the guidance document, it is useful to reflect on the work required before any actual assessment begins. A significant portion of the work required in conducting a CVA occurs before a single resource is assessed. Managers should be aware of this capacity requirement and plan accordingly (see Appendix A for an example timeline and list of tasks).

6.3 Assessing Sensitivity and Exposure

While they are two separate factors, the sensitivity and exposure of a resource to hazards are often assessed together. This is both because these two factors together determine the potential impact of a hazard on a resource (Figure 1, see Chapter 2), and because it is easier for participants to assess the sensitivity and exposure of a resource to one hazard type (climate or non-climate) before moving on to the next. It is important to remember that the sensitivity of a resource to a hazard is a measure of whether and how it is likely to be affected by a given change in that hazard while its exposure to that hazard is a measure of how much change or amount of that hazard it is likely to experience or, for non-climate hazards, currently experiences (see Chapters 2.1 and 2.2). Some factors, particularly when assessing living resources, could be seen as either affecting a resource's sensitivity or adaptive capacity. As a general rule, *if the factor being assessed represents how a hazard is or is expected to affect a resource, it is assessed under sensitivity while if it represents how a resource responds to the effect of a hazard, it is assessed under adaptive capacity* (see Chapter 2.3 for further exploration of this topic). As such, the assessment of sensitivity in extensive and limited scope CVAs is limited to the effect of climate and non-climate hazards on a resource and reserves the assessment of other factors that could be seen as affecting a resources sensitivity to climate factors (e.g., a species' life history) to the assessment of adaptive capacity. The methods for assessing sensitivity and exposure differ between extensive and limited scope CVAs and are explored separately below.

6.3.1 Extensive Scope CVA

The manner in which sensitivity and exposure are assessed during an extensive scope CVA differs slightly depending on resource type (i.e., species, habitat, ecosystem service, heritage resource). This is because an extensive CVA allows for the time and flexibility to frame questions that are applicable only to a particular resource type. Despite these slight differences, which can be explored in the example worksheets provided in Appendix A, the basic process for assessing sensitivity to a hazard is the same.

For each hazard, including both those presented to participants and any others they feel are important to consider (see Chapter 4.3), participants note whether the resource is sensitive to that hazard (yes/no), the degree to which it is sensitive, and the confidence they have in this assessment of sensitivity (Figure 4, full example sheet can be found in Appendix A). The degree of sensitivity is assigned a value from 1 (very low) to 5 (very high). These numbers are later used to determine an overall sensitivity which is in turn used to calculate the potential impact. Confidence is given a score from 1 (low) to 3 (high). This score is used to communicate the degree of confidence that participants have in their assessment of sensitivity and can be influenced by factors such as level of agreement among participants and level of information available.

Exposure is assessed in a very similar manner to sensitivity. For each climate hazard, participants assess the degree of exposure that the resource is likely to experience over the timescale of the assessment from 1 (very low) to 5 (very high) as well as the confidence, from 1 (low) to 3 (high), in that assessment of exposure. Exposure to non-climate hazards is assessed in the same way except that current exposure is assessed, rather than future exposure, as future changes to non-climate stressors are often very difficult or impossible to predict with any level of confidence. An example of how sensitivity and exposure are assessed can be found in Box 6a.

The overall sensitivity and exposure scores can be determined in numerous ways during an extensive CVA. The most straightforward approach is to take the average sensitivity and exposure scores of all assessed hazards. This allows for a traceable, quantitative value that is easily defendable. However, it assumes that all hazards contribute equally to the sensitivity and exposure of the resource. Another approach is to ask participants to determine an overall score for sensitivity and exposure after assigning, and informed by, the individual values. In this strategy, participants look back on and consider the full list of sensitivity and exposure values assigned to individual hazards and assign one overall value each for sensitivity and exposure. This strategy allows participants to consider the relative importance of different factors in the overall sensitivity and exposure of a resource. This strategy for assigning overall sensitivity and exposure works well during an extensive CVA, where many hazards are considered. When employing this strategy, it is still important to assign sensitivity, exposure, and confidence values to individual hazards as this allows participants to better determine overall values. This approach also documents which hazards drive the resource's vulnerability, critical to exploring management actions (see Chapter 7). A third strategy involves aspects of both the previously described methods. Participants are asked to determine an overall score, which is then compared to the calculated average score of all assessed hazards. If the scores differ significantly, participants can then discuss why this is the case (e.g., one score weighed heavily on the participant-determined overall score but was washed out in the averaged score). Such a method can help to highlight hazards that participants feel are of particular importance. To save time, this strategy can also be employed by comparing the average score to a participant-determined overall score after the workshop and following up with participants if the scores differ significantly.

Please prioritize the gray boxes in each section. If time is limiting, the project team may also populate the non-gray fields, although we might ask for participants to review answers later.

Species: ____

1. Sensitivity to Climate Hazards

***Please Note: Sensitivity is a measure of whether and how a species is likely to be affected by a given change in climate or another environmental hazard. Exposure (covered in another section below) addresses how much change in climate or another environmental hazard a species is likely to experience.**

Consider both direct (e.g., physiology) and indirect (e.g., ecological relationships) sensitivities of the species. Physiological sensitivity reflects the impacts that a climate hazards may have on a species' physiology. Species life history or behavior may also be affected by climate hazards. Species' ecological relationships may also be affected by climate or climate-driven factors. Ecological relationships could include: predator/prey, foraging, competition, habitat, pollination, dispersal, symbiont/mutualist/parasite, and others.

Please evaluate the sensitivity of the species to the following climate hazards. IF THE SPECIES IS NOT SENSITIVE TO THE FACTOR, PLEASE WRITE "N" AND LEAVE THE ROW BLANK.

CLIMATE HAZARD	SENSITIVE TO FACTOR (Y/N)	DEGREE OF SENSITIVITY 1 (very low) – 5 (very high)	CONFIDENCE 1 (low) – 3 (high)	RELEVANT REFERENCES
Air temperature				
Sea surface temperature				
Precipitation				
Salinity				
Deoxygenation				
pH				
Sea level rise				
Wave action				
Upwelling				
Currents/mixing/ stratification				
Coastal erosion				
Other (please specify)				

Figure 4. Extensive CVA species sensitivity table. See Appendix A for full worksheet. Image: NOAA

Box 6a: Assessing Sensitivity and Exposure During an Extensive CVA – Bull Kelp

A breakout group is assessing the sensitivity and exposure of bull kelp to a variety of climate and non-climate hazards over the next 50 years using a species CVA worksheet (Figure 5). Using their expertise and other information about relevant hazards and bull kelp presented during the workshop, the group determined that bull kelp was sensitive to a number of climate hazards with varying levels of sensitivity. For example, bull kelp's sensitivity to sea surface temperature was rated as very high (5) with high (3) confidence as there is abundant scientific research documenting this sensitivity. In contrast, it was assessed to have a low (2) degree of sensitivity to sea level rise, but with low (1) confidence as there is very little research on this subject. In a separate section of the same worksheet (see worksheets in Appendix A), the group assesses the degree to which bull kelp is likely to be exposed to the assessed climate hazards over the next 50 years. Among others, the group determined that bull kelp will have a high exposure to sea surface temperature (4), with high confidence (3), and medium exposure to sea level rise (3) with medium confidence (2). These exposure values were determined based on scientific projections of changes to these hazards in the MPA, which were presented to participants by a climate change expert.

In addition to climate hazards, the breakout group also determined that there are three relevant non-climate stressors that are likely to affect bull kelp: harvest, invasive species, and the formation of urchin barrens (Figure 6). For each, the group determined a sensitivity and exposure in the same manner as for climate hazards based on their subject and local expertise on these hazards.

After the discussions of bull kelp's sensitivity and exposure to individual hazards, the group discussed its overall sensitivity and exposure. There were many hazards for which bull kelp was determined to have relatively high sensitivity, as well as a number for which it was determined to have relatively low sensitivity. Through discussion and exploration of the individual values, the group determined that many of the hazards for which sensitivity was low had high uncertainties and that some of the hazards to which bull kelp was highly sensitive could have drastic effects. Thus, the group assigned an overall high sensitivity (4) and had medium confidence (2) in this assessment (Figure 7). After a similar discussion, it was determined that bull kelp was likely to have an overall medium exposure (3) to hazards over the next fifty years, a determination for which the group had medium confidence (2) (Figure 7). Thus, the final assessment of sensitivity and exposure for bull kelp was:

Sensitivity: 4 (high)

Exposure: 3 (medium)

Species: Bull Kelp

1. Sensitivity to Climate Hazards

***Please Note: Sensitivity is a measure of whether and how a species is likely to be affected by a given change in climate or another environmental hazard. Exposure (covered in another section below) addresses how much change in climate or another environmental hazard a species is likely to experience.**

Consider both direct (e.g., physiology) and indirect (e.g., ecological relationships) sensitivities of the species. Physiological sensitivity reflects the impacts that a climate hazards may have on a species' physiology. Species life history or behavior may also be affected by climate hazards. Species' ecological relationships may also be affected by climate or climate-driven factors. Ecological relationships could include: predator/prey, foraging, competition, habitat, pollination, dispersal, symbiont/mutualist/parasite, and others.

Please evaluate the sensitivity of the species to the following climate hazards. IF THE SPECIES IS NOT SENSITIVE TO THE FACTOR, PLEASE WRITE "N" AND LEAVE THE ROW BLANK.

CLIMATE HAZARD	SENSITIVE TO FACTOR (Y/N)	DEGREE OF SENSITIVITY 1 (very low) – 5 (very high)	CONFIDENCE 1 (low) – 3 (high)	RELEVANT REFERENCES
Air temperature	Y	1	1	
Sea surface temperature	Y	5	3	
Precipitation	Y	1	1	
Salinity	Y	5	2	
Deoxygenation	Y	5	3	
pH	Y	5	3	
Sea level rise	Y	2	1	
Wave action	Y	5	3	
Upwelling	Y	4	2	

Do any of the climate or climate-driven factors listed above BENEFIT the species? If so, please list the factor and describe how the species benefits. Please include any relevant citations.	Increased pCO2 (OA) could enhance growth
Overall, to what degree is the species sensitive to climate and climate-driven factors? *Given your experience and knowledge, what would be your gut assessment for this species? Just express your opinion. 1 – 5 (1=low degree; 5=high degree)* 4	**Confidence in your overall assessment of the sensitivity of the species to climate and climate-driven factors:** *1 – 3 (1=low confidence; 3=high confidence)* 2

Figure 5. Example of a completed extensive CVA analysis of sensitivity to climate hazards. Image: NOAA

3. Sensitivity and Current Exposure to Non-Climate Hazards

Sensitivity of the species to climate hazards may be highly influenced by the existence, extent of, and exposure to non-climate stressors. For non-climate hazards, exposure is the current level of impact is experienced by the species

Using the list provided, please write the non-climate hazards most likely to increase sensitivity of the species to climate change in the table below.

- ~~Ocean Sound~~
- Harvest/Fishing
- ~~Submarine Cables~~
- Aquaculture
- Marine Debris
- Recreation/Increased Visitation
- Other (please specify) Formation of urchin barrens
- Maritime Transportation
- Military Activities
- ~~Contaminants~~
- Invasive and other problematic species
- ~~Offshore Energy~~
- Research Activities

NON-CLIMATE STRESSOR	DEGREE STRESSOR AFFECTS SENSITIVITY 1 (very low) – 5 (very high)	CONFIDENCE 1 (low) – 3 (high)	DEGREE OF CURRENT EXPOSURE 1 (very low) – 5 (very high)	CONFIDENCE 1 (low) – 3 (high)
Harvest	1	2	1	2
Invasive Species	5	3	2	2
Formation of urchin barrens	5	3	5	3

Overall, to what degree do these non-climate stressors make the species more sensitive to climate change? *1 – 5 (1= very low degree; 5= very high degree)* 4	**Confidence in your overall assessment of the degree to which non-climate stressors affect the species' sensitivity:** *1 – 3 (1=low confidence; 3=high confidence)* 3
Comments and Citations: *Please briefly describe how each of the hazards selected above are likely to make the species more sensitive to climate change. If the hazard occurs only in localized areas, please identify those locations.*	

Figure 6. Example of a completed extensive CVA analysis of sensitivity to non-climate hazards. Image: NOAA

4. Overall User Ranking of Sensitivity

In your opinion, how would you rank the overall sensitivity of this species? *Given your experience and knowledge, what would be your gut assessment for this species? Just express your opinion. 1 – 5 (1= very low sensitivity; 5= very high sensitivity)* 4	**Confidence in your overall assessment of the sensitivity of this species:** *1 – 3 (1=low confidence; 3=high confidence)* 2
Comments:	

5. Overall User Ranking of Exposure

In your opinion, how would you rank the overall exposure of this species? *Given your experience and knowledge, what would be your gut assessment for this species? Just express your opinion. 1 – 5 (1= very low exposure; 5= very high exposure)* 3	**Confidence in your overall assessment of the exposure of this species:** *1 – 3 (1=low confidence; 3=high confidence)* 2
Comments:	

Figure 7. Example of completed extensive CVA overall sensitivity and exposure rankings. Image: NOAA

6.3.2 Limited Scope CVA

The manner in which sensitivity and exposure are assessed during a limited scope CVA is very similar across resource type (i.e., species, habitat, ecosystem service, heritage resource). This allows for a similarity between worksheets that facilitates a faster assessment when moving between resource types. Small differences do exist between the worksheets allowing for the assessment of factors applicable only to a particular resource type. These differences are minor and often involve only a change in framing. These small differences can be explored in the example worksheets provided in Appendix A. Regardless of resource type, the process for assessing the sensitivity and exposure of a resource to hazards during a limited scope CVA is the same.

First, the climate and non-climate hazards to be assessed must be chosen. Managers can either choose the hazards to be assessed ahead of the workshop, or allow participants to select the hazards to be assessed from a predetermined list (Figure 8). Further, a choice must be made whether to assess the same hazards for all focal resources, or to allow for different hazards to be assessed for each resource. If different hazards are selected for each resource, participants select the hazards to be assessed as the first step in the assessment of that resource, often within breakout groups. Managers can also elect to include space for participants to select hazards that are not on the predetermined list. This is often useful as subject matter experts may be aware of hazards that were not previously considered. Regardless of the method employed for hazard selection, only three climate and three non-climate hazards should be selected for each focal resource to be assessed.

Hazard Selection Table

Resource:

Climate Hazards	Selected Hazards
Warming Water Temperatures	
Ocean Acidification	
Deoxygenation/Decreasing Oxygen Levels	
Sea Level Rise	
Altered Precipitation	
Altered Currents	
Altered Upwelling/Mixing (incl. Stratification)	
Changing Salinity	
Changing Turbidity	
Changing Wave Action	
Increasing Coastal Erosion	
Changing Storm Frequency and/or Severity	
Harmful Algal Blooms (HABs)	
Changing Large-Scale Climate Processes (e.g., ENSO, PDO)	

Non-Climate Hazards	Selected Hazards
Nutrient Pollution	
Terrestrial Non-Nutrient Pollution	
Marine-Sourced Pollution and Spills	
Coastal Development/Population Growth	
Commercial Harvest	
Non-Commercial Harvest	
Tourism and/or Recreation	
Aquaculture	
Disease	
Invasive Species	
Transportation/Shipping	
Oil, Mineral, and Gas Extraction	
Energy Production (e.g., offshore wind, wave energy, etc.)	
Ocean Noise	
Coastal Armoring	
In-Water Structures	
Dredging	
Boat/Ship Grounding	
Changes to Sediment Transport	
Researcher Disturbance	
Carbon Dioxide Removal Infrastructure	
Other:	

Figure 8. Limited CVA hazards selection table. See Appendix A for full worksheet. Image: NOAA

During a limited scope CVA, participants assess the vulnerability of focal resources through a series of tables. Each focal resource will be assessed using an independent set of tables. The primary table (Figure 9) is used to collate information from the other tables, and to assess both sensitivity and exposure to climate hazards. Before assessing exposure and sensitivity, it is first necessary to complete the first three columns of the primary table. After listing the three climate hazards to be assessed in column 1 of the primary table, participants then determine how that hazard is expected to change over the timeframe and in the area being assessed and list this information in column 2. This information is often provided as background during the workshop (see Chapter 6.2), but can also be determined or influenced using the expert knowledge of the participants. The anticipated effects of the hazard on the focal resource, which may also have been provided as background information, is then discussed and listed in column 3. While these first three columns largely contain background information, filling out these columns is important. The discussions required to fill these columns help ensure participants are on the same page and fully engaged, may result in additional information important to the assessment derived from the expert knowledge of the participants, and provide important context for the final assessment which is useful for writing the CVA report and determining adaptation actions (see Chapters 7 and 8).

Participants assess the exposure of the resource being assessed to climate hazards in column 4 of the primary table. For each climate hazard, participants assess the degree of exposure that the resource is likely to experience over the timescale of the assessment, and the confidence they have in this assessment of exposure. The degree of exposure is assigned a value from 1 (very low) to 5 (very high). Confidence is given a score from 1 (low) to 3 (high). This score is used to communicate the degree of confidence that participants have in their assessment of exposure and can be influenced by factors such as the level of agreement among participants and the level of information available. After assigning exposure and confidence values to each hazard, the overall exposure of the resource is calculated as the average of the three individual exposure scores.

Participants assess the focal resource's sensitivity to hazards using the sensitivity table (Figure 10). This table allows for the determination of the resource's sensitivity to the assessed climate hazards in combination with impacts of non-climate hazards. In the sensitivity table, the three non-climate hazards to be assessed are first listed in column 1. Participants then discuss, and record, how each of these hazards affect the focal resource (column 2) and if climate change will make these effects better or worse, from the perspective of the focal resource (column 3). It is useful for participants to also record why they came to this determination in column 3 as it can later inform the report narrative and the development of management actions. *Note that the effects of the non-climate hazards on the resource recorded in column 2 are the current effects rather than future effects*. The sensitivity to non-climate hazards (i.e., the potential future impact) is not directly assessed as changes to non-climate hazards can be difficult or impossible to reliably project. Rather, a limited CVA assesses how climate hazards are likely to alter the impact of non-climate hazards on the focal resource (column 3) and uses the interaction of these hazards to inform the assessment of sensitivity (column 4). In column 4, the participants enter one of the climate hazards being assessed into each of the three sub-column headings. For each interaction of climate and non-climate hazards, the participants discuss and record how the combination of these hazards may impact the focal resource. For example, if participants are assessing the interaction of disease and increasing water temperature on coral, they may state that warming can increase the susceptibility of corals to disease while disease can stress corals thus enhancing the likelihood that warming will lead to bleaching.

Primary Table

Resource: **Timescale:**

Climate hazard	Observed or projected direction and magnitude of change in hazard	Impacts of hazard on resource	Exposure	Sensitivity (from sensitivity table)	Potential Impact	Adaptive Capacity (adaptive capacity table)	Vulnerability (list key drivers)
		Average/Overall:					

Figure 9. Limited CVA primary table. See Appendix A for full worksheet. Image: NOAA

Sensitivity Table

Resource: **Timescale:**

Non-climate hazard	Impacts of hazard on resource	Will climate change make impact of hazard better or worse?	Combined impact of non-climate hazard and climate hazards (list below)		
		Sensitivity: (transfer to column 5 of Primary Table)			

Figure 10. Limited CVA sensitivity table. See Appendix A for full worksheet. Image: NOAA

After assessing the impacts of each of the climate and non-climate hazards on the focal resource, participants review the impacts listed for each of the climate hazards in column 4 and assign a sensitivity to each hazard in the bottom row labeled "sensitivity." In this way, the sensitivity value that is eventually assigned to each climate hazard in the primary table is inclusive of the sensitivity of the resource to the non-climate hazards assessed. Similar to exposure, the sensitivity of the focal resource to each climate hazard is assigned a score from 1 (very low) to 5 (very high) and a confidence in that rating from 1 (low) to 3 (high). These scores are then transferred to column 5 of the primary table in the row corresponding to the appropriate climate hazard. The overall sensitivity of the resource can then be calculated by taking the average of these three scores. An example of how sensitivity and exposure may be assessed can be found in Box 7a.

Box 7a: Assessing Sensitivity and Exposure During a Limited CVA – Coral Reef

A breakout group is assessing the sensitivity and exposure of a shallow coral reef habitat to a variety of climate and non-climate hazards over the next 25 years using a series of limited scope habitat CVA tables. Using a list of climate hazards provided by the workshop organizers, the group has decided to assess the vulnerability of the habitat to increased water temperature, ocean acidification, and changes to tropical storm frequency and intensity (Figure 11). The participants chose these hazards as they believe them to be the most likely to impact the habitat, and thus the most important to assess. Using their expertise and other information about the chosen hazards and the MPA's coral reefs presented during the workshop, the group determines that warming and ocean acidification are likely to increase in the next 25 years, and that both are likely to have negative impacts on the coral habitat. They also determine, with high confidence (3) that the coral habitat is likely to have very high (5) exposure to warming and medium (3) exposure to ocean acidification over this timeframe. They record all of this information in the appropriate columns of the primary table. The picture for storms is more complicated, as the projections over the assessed timeframe are very uncertain while also suggesting increasing storm strength, which would have a negative impact on the coral habitat, but decreasing frequency, which would have a net positive effect. Thus, after discussion, the group assigns a low exposure (2) with low confidence (1).

The breakout group then turns to the sensitivity table (Figure 12) to assess the sensitivity of the coral habitat to the three climate hazards in combination with three non-climate hazards: pollution, commercial fishing, and invasive species. The group discusses the impacts of these non-climate hazards on the coral habitats in the MPA and determines that all three have negative impacts on the habitat. They also determine that climate change is likely to make pollution and invasive species worse, but that climate change will decrease commercial fishing pressure (making it better from the view of the habitat) as the primary target species of the fishery is expected to shift out of the region. Once they record these discussions in the appropriate columns of the sensitivity table, they discuss the interactive impacts of warming temperatures and each of the non-climate hazards on the coral habitat. They are uncertain if warming will have an effect on the amount of fishing, but note that warming could make it easier for species to invade and also lead to increased pollution at the same time as it makes it more difficult for the species in the coral habitat to cope with these hazards. They record these and other determinations under the "increasing water temp." sub-heading of column 4. Upon reviewing their discussion of the combined impacts of warming and non-climate hazards on the coral reef habitat, they conclude that the habitat has a very high (5) sensitivity to warming and have high (3) confidence in this rating. Using the same method of discussion, they also determine that the coral reef habitat has a medium (3) sensitivity to ocean acidification and a high (4) sensitivity to storms, both with medium (2) confidence. The group then transfers these sensitivity values to the appropriate row of column 5 in the primary table (Figure 9).

Primary Table

Habitat: Shallow Coral Reef **Timescale:** 25 Years (2047)

Climate hazard	Observed or projected direction and magnitude of change in hazard	Impacts of hazard on resource	Exposure	Sensitivity (from sensitivity table)	Potential Impact	Adaptive Capacity (adaptive capacity table)	Vulnerability (list key drivers)
Increased Water Temperature	Increase	Overall negative including increased bleaching and stress. Could increase disease	5 (High confidence)	5			
Ocean Acidification	Increase	Decreased calcification, increased stress. Could lead to dissolution. Overall negative	3 (High confidence)	3			
Changes to Storm Frequency & Intensity	Increasing intensity, but fewer storms Projections are uncertain	Stronger storms could increase damage to coral. Fewer storms could benefit coral	2 (Low confidence)	4			
		Average/Overall:	3.3	4			

Figure 11. Example of limited CVA habitat primary table completed through the analysis of sensitivity and exposure. Image: NOAA

To calculate the overall exposure to climate hazards that the coral reef habitat is likely to experience in the next 25 years, the group takes the average of the three exposure values in column 4 of the primary table. This results in an overall exposure of 3.3, which would be considered “medium” as it rounds down to 3. Overall sensitivity is calculated in the same manner using the values recorded in column 5 of the primary table, resulting in a “high” value of 4. Thus, the final assessment for the shallow coral reef habitat was:

Sensitivity: 4 (high)

Exposure: 3.3 (medium)

Sensitivity Table

Habitat: Shallow Coral Reef **Timescale:** 25 Years (2047)

Non-climate hazard	Impacts of hazard on resource	Will climate change make impact of hazard better or worse?	Combined impact of non-climate hazard and climate hazards (list below)		
			Increasing Water Temp.	Ocean Acidification	Changing Storms
Pollution	Negative impacts on coral. Can cause stress/bleaching Increases disease Can kill coral Can lead to HABS	Worse More extreme precipitation likely to increase runoff	Makes effects of pollution worse(?) Could increase lawn watering and runoff	May make effects worse	More intense rain events likely to increase runoff
Commercial Fishing	Negative impacts Can damage coral Removes herbivores and large predators key to habitat health	Improved Main target species expected to move out of MPA	Uncertain if direct impact but could cause target spp. to shift out of MPA, which could decrease fishing	Can't think of any direct effects May negatively affect target spp.(?)	Strong storms could damage fleet
Invasive Species	Negative impacts Alters ecosystem Some could prey on or damage coral Competition for space	Worse Warming and acidification could facilitate invasion	Could facilitate invasion	Could facilitate invasion. May slow invasion of calcifying invaders	Storms can facilitate invasion
		Sensitivity: (transfer to column 5 of Primary Table)	5 (High confidence)	3 (Medium confidence)	4 (Medium confidence)

Figure 11. Example of completed limited CVA habitat sensitivity table. Image: NOAA

6.4 Calculating Potential Impact

Calculating potential impact is nearly the same for both CVA scopes. For both scopes, a matrix approach (Figure 13) is used with sensitivity on one axis and exposure on the other. Participants find where these values intersect and this determines the potential impact that the resource is likely to experience over the assessed timeframe. During an extensive CVA, potential impact is calculated as a function of the overall sensitivity and exposure assessed for the focal resource.

Potential Impact

Exposure →

Sensitivity↓	*Very Low (1)*	*Low (2)*	*Medium (3)*	*High (4)*	*Very High (5)*
Very Low (1)	Very Low (1)	Very Low (1)	Low (2)	Medium (3)	Medium (3)
Low (2)	Very Low (1)	Low (2)	Low (2)	Medium (3)	High (4)
Medium (3)	Low (2)	Low (2)	Medium (3)	High (4)	High (4)
High (4)	Low (2)	Medium (3)	High (4)	High (4)	Very High (5)
Very High (5)	Medium (3)	Medium (3)	High (4)	Very High (5)	Very High (5)

Figure 13. Matrix used to determine potential impact from exposure and sensitivity. Image: NOAA

Box 6b: Calculating Potential Impact During an Extensive CVA– Bull Kelp

The participants in the bull kelp breakout group previously assessed the sensitivity of bull kelp over the next 50 years to be high (4) and its exposure to be medium (3) (Box 6a). Thus, they use the potential impact matrix to find that this combination of sensitivity and exposure results in bull kelp experiencing a high (4) potential impact (Figure 14).

Potential Impact: 4 (high)

6. Potential Impact

Calculate the Potential Impact likely to be experienced by the species using your values of Sensitivity (Box 4) and Exposure (Box 5) using the table below:

Potential Impact

Exposure →

Sensitivity↓	*Very Low (1)*	*Low (2)*	*Medium (3)*	*High (4)*	*Very High (5)*
Very Low (1)	Very Low (1)	Very Low (1)	Low (2)	Medium (3)	Medium (3)
Low (2)	Very Low (1)	Low (2)	Low (2)	Medium (3)	High (4)
Medium (3)	Low (2)	Low (2)	Medium (3)	High (4)	High (4)
High (4)	Low (2)	Medium (3)	High (4)	High (4)	Very High (5)
Very High (5)	Medium (3)	Medium (3)	High (4)	Very High (5)	Very High (5)

Potential Impact: 4

Figure 14. Example of completed potential impact determination for an extensive CVA. Image: NOAA

During a limited scope CVA, potential impact is first calculated independently for each climate hazard (primary table column 6; Figure 9). Overall potential impact can then be determined as either the average of these individual values or as a function of the previously calculated overall sensitivity and exposure by using a matrix (Figure 13). These methods rarely result in differing qualitative values of potential impact (i.e., low vs medium), but can result in different quantitative values. Thus, it is important to decide which method will be used prior to the workshop and employ the same method across all breakout groups and for all resources.

Box 7b: Calculating Potential Impact During a Limited CVA – Coral Reef

The participants in the shallow coral reef breakout group previously assessed the sensitivity and exposure of the habitat to each of the climate hazards independently, and calculated overall values, over the next 25 years (Box 7a). The group first determines the potential impact of each of the three climate hazards independently. The sensitivity of the shallow coral reef habitat to changing storm patterns was previously assessed as high (4) with a low (2) exposure. Using the potential impact matrix, the breakout group finds that this combination of sensitivity and exposure results in the habitat experiencing a medium (3) potential impact from changing storm patterns (Figure 15). They run the same analysis for the other climate hazards and determine that the habitat will experience a very high (5) potential impact from warming and a medium (3) potential impact from ocean acidification. As instructed by the organizers, the group takes the average of these three impact values to determine that the shallow coral reef habitat will experience a high (3.7) overall potential impact. They also note that if they had used the averaged overall sensitivity (3.3) and exposure (4) values that they calculated previously (Box 7a), they would have also concluded that the potential impact was high but would have assigned it a quantitative value of 4 as a result of using the matrix.

Potential Impact: 3.7 (high)

Potential Impact

Exposure →

Sensitivity↓	*Very Low (1)*	*Low (2)*	*Medium (3)*	*High (4)*	*Very High (5)*
Very Low (1)	Very Low (1)	Very Low (1)	Low (2)	Medium (3)	Medium (3)
Low (2)	Very Low (1)	Low (2)	Low (2)	Medium (3)	High (4)
Medium (3)	Low (2)	Low (2)	Medium (3)	High (4)	High (4)
High (4)	Low (2)	Medium (3)	High (4)	High (4)	Very High (5)
Very High (5)	Medium (3)	Medium (3)	High (4)	Very High (5)	Very High (5)

Figure 15. Example of a limited CVA potential impact determination of one hazard. Image: NOAA

6.5 Assessing Adaptive Capacity

The adaptive capacity of a resource is a measure of its ability to adapt to the impacts of climate change or other hazards. Together with the potential impact, adaptive capacity determines the vulnerability of a resource being assessed (Figure 1, see Chapters 2.3 and 2.4). When assessing adaptive capacity, participants should consider factors that are both intrinsic to the resource as well as those that are extrinsic. Intrinsic adaptive capacity factors are those that the resource possesses independent of outside factors, such as the thermal tolerance of an organism or the ability of a community to switch harvest species. Extrinsic adaptive capacity factors are those that are independent of the resource itself, such as management actions or the flexibility of policy levers (for a more on adaptive capacity, see Chapter 2.3). Assessing both intrinsic and extrinsic adaptive capacity factors allows for the eventual exploration of management actions that can address both how resources react to climate hazards (intrinsic) and how humans react in a way that affects resources (extrinsic).

As discussed in chapter 2.3, in some CVA models, intrinsic factors can be viewed as affecting a resource's sensitivity, particularly for living resources. For example, if a species has a generalist diet, this could be seen as imparting a higher intrinsic adaptive capacity to that species or reducing its sensitivity to climate hazards. However, not all intrinsic, and few extrinsic adaptive capacity factors could be reasonably viewed through the lens of a resource's sensitivity. For example, the cultural value of a resource does not affect its sensitivity, but it does affect the resources' extrinsic adaptive capacity. To ensure that there is consistency in how factors are assessed, *this guidance document strongly suggests that any factor that could be assessed as a factor of adaptive capacity is assessed as such*, rather than as a factor affecting sensitivity. Not only does this strategy prevent arbitrary delineations of intrinsic factors, it also allows for consistency and greater ease of scoring during the vulnerability assessment. A good rule of thumb is that if a factor represents how a hazard is or is expected to affect a resource, it should be assessed under sensitivity. If a factor represents how a resource or manager responds to the effect of a hazard, it should be assessed under adaptive capacity.

To address both intrinsic and extrinsic factors, the assessment of adaptive capacity often requires a mix of information that can be gathered prior to the workshop, such as scientific data on species life histories or thermal tolerances, and that which can only be determined through subject matter expertise, such as the flexibility of management and policy to address hazards. This can make adaptive capacity more challenging, and in many ways more engaging, to assess than sensitivity and exposure. The methods for assessing adaptive capacity differ between extensive and limited scope CVAs and are explored separately below.

6.5.1 Extensive Scope CVA

The manner in which adaptive capacity is assessed during an extensive scope CVA differs slightly depending on resource type (i.e., species, habitat, ecosystem service, heritage resource). This is because the nature of an extensive CVA allows for the time and flexibility to frame questions that are specifically applicable to particular resource types. For example, dispersal ability, life history, and genetic diversity are often factored into the assessment of a species' adaptive capacity but are not relevant to the assessment of ecosystem services. Similarly, the cultural value of ecosystem services may be relevant to assessing their adaptive capacity but less-so for species and habitats. Alternatively, some aspects of adaptive capacity, like the flexibility of rules governing management, are likely to be applicable to the assessment of all resources. Despite these factors, which can be explored in the example worksheets provided in Appendix A, the basic process for assessing adaptive capacity is the same for all resources.

For each aspect of adaptive capacity, participants assign a value between 1 (very low) and 5 (very high) and a confidence score of 1 (low) to 3 (high). The precise significance of the adaptive capacity value will differ between factors of adaptive capacity being assessed, but *the higher the number, the more benefit that factor provides to the resource being assessed*. For example, if the factor being assessed is a species' genetic diversity or connectivity, or perhaps the value that people place on an ecosystem service, a designation of "1" could correspond to very low and "5" to very high. Alternatively, if the factor being assessed is the likelihood of the management agency being able to alleviate climate hazards on the resource, "1" may correspond to a very low likelihood while "5" would denote a very high likelihood. Regardless of the descriptor being used, an adaptive capacity rating of 1 corresponds to a very low ability of the assessed factor to aid the resource in its capacity to adapt while a rating of 5 corresponds to a very high ability to do so. An example of how adaptive capacity could be assessed can be found in Box 6c.

The overall adaptive capacity score can be determined in a few ways during an extensive CVA. The most straightforward approach is to take the average adaptive capacity scores of all factors that were assessed for the resource. This allows for a traceable, quantitative value that is easily defendable. However, it assumes that all factors contribute equally to the adaptive capacity of the resource. Another approach is to ask participants to determine an overall score for adaptive capacity after assigning, and informed by, individual values. In this strategy, participants look back on and consider the full list of adaptive capacity values assigned to the assessed factors, and the conversations surrounding them, and assign one value for overall adaptive capacity. This strategy allows participants to consider the relative importance of different factors in the overall adaptive capacity of a resource. This method for assigning overall adaptive capacity works well during an extensive CVA as many factors are considered and additional factors can be added during discussion, which often occurs during the assessment of adaptive capacity. When employing this strategy, it is still important to assign adaptive capacity and confidence values to each assessed factor as this allows participants to better determine overall values and facilitates the detailed exploration of which factors drive the resource's adaptive capacity that is critical to exploring management actions (see Chapter 7). A third strategy involves aspects of both previously described methods. Participants are asked to determine an overall score, which is then compared to the average score of all the assessed adaptive capacity factors. If the scores differ significantly, participants then discuss why this is the case (e.g., one score weighed heavily on the participant-determined overall score but was washed-out in the averaged score). Such a method can help to highlight factors that participants feel are of particular importance to a resource's adaptive capacity. To save time, this strategy can also be employed by comparing the average score to a participant-determined overall score after the workshop and following up with participants if the scores differ significantly.

Box 6c: Assessing Adaptive Capacity During an Extensive CVA – Bull Kelp

Participants in the bull kelp breakout group have finished assessing the sensitivity and exposure of bull kelp to climate and non-climate hazards (Box 6a) and calculating the potential impact it is likely to experience over the next 50 years (Box 6b). It is now time for the group to assess the adaptive capacity of bull kelp, the final piece in determining the resource's vulnerability. To assess bull kelp's adaptive capacity, the breakout group uses a species CVA worksheet (Figure 16). There are many potential factors that influence bull kelp's adaptive capacity, and the group uses their subject matter expertise and the information presented during the workshop to assign an adaptive capacity score from 1 (very low) to 5 (very high), and a confidence value from 1 (low) to 3 (high) in that score, to each factor. For example, the group determines that bull kelp has a very broad geographic extent, which can help increase the adaptability of a species. Thus, they assign a very high adaptive capacity value of 5 related to the geographic extent of bull kelp. They also have high confidence (3) in this value. In contrast, they determine that bull kelp has an overall low phenotypic plasticity, which if high could increase its adaptive capacity, and thus assign a low adaptive capacity score of 2 to this value, although they have low confidence (1) in this determination due to a relative dearth of scientific studies.

7. Intrinsic Adaptive Capacity

***Please Note: Adaptive Capacity is a measure of the ability of a species to adapt to the effects or impacts of an environmental or climate hazard. The INTRINSIC adaptive capacity of a species includes those factors that are inherent to the species itself while EXTRINSIC adaptive capacity (covered in another section below) includes those factors that are external to the species but can affect its adaptive capacity.**

Please evaluate the following intrinsic adaptive capacity factors. A higher score signifies that this factor as it applies to the species being evaluated will increase its adaptive capacity. For example, a species with high genetic diversity may be better able to adapt to climate hazards. For such a species, the adaptive capacity score for genetic diversity would be higher than for a species with low genetic diversity. See the supplemental tables for exercises that can help determine these factors if needed.

CHARACTERISTIC	Adaptive Capacity 1 (very low) – 5 (very high)	CONFIDENCE 1 (low) – 3 (high)	COMMENTS AND RELEVANT REFERENCES
Life history strategy	1	3	
Genetic Diversity	3	1	
Behavioral Plasticity			Not assessed, not likely applicable
Phenotypic Plasticity	2	1	
Distribution/Extent	5	3	Very broad geographic range
Population Connectivity	4	2	
Dispersal Ability	5	3	
Dependencies (Generalist/Specialist)	5	2	
Population Status	3	1	
Other:			

Overall, what is the degree of intrinsic adaptive capacity? *1 – 5 (1=very low adaptive capacity; 5=very high adaptive capacity)* 3	**Confidence in your overall assessment of intrinsic adaptive capacity:** *1 – 3 (1=low confidence; 3=high confidence)* 2

Figure 16. Example of completed extensive CVA species intrinsic adaptive capacity table. Image: NOAA

The group also assesses extrinsic adaptive capacity factors (see worksheets in Appendix A). They determine, with high confidence (3) that people place very high value on this species. Thus, they assign an adaptive capacity value of 5 for this factor as this could increase the interest people have in maintaining bull kelp, and thus the resources they bring to bear in order to do so. In contrast, they determined that the ability of managers to alleviate the impacts that most affect bull kelp, in this case temperature rise, is low, with medium confidence (2). Thus, they assign an adaptive capacity value of 2 to this extrinsic factor.

After these discussions of factors influencing adaptive capacity, the group discusses the overall adaptive capacity of bull kelp. There were a number of factors that the group determined increased the adaptive capacity of bull kelp, but with relatively low confidence, while for numerous factors bull kelp was found to have relatively low adaptive capacity with relatively high confidence. Thus, the group assigned an overall low (2) adaptive capacity value and had medium confidence (2) in this assessment (Figure 17).

Adaptive capacity: 2

9. Overall User Ranking of Adaptive Capacity

In your opinion, how would you rank the overall adaptive capacity of this species to climate change? *Given your experience and knowledge, as well as your assessment of intrinsic and extrinsic adaptive capacity factors, what would be your gut assessment for this species? 1 – 5 (1=very low adaptive capacity; 5=very high adaptive capacity)* 2	**Confidence in your overall assessment of the adaptive capacity of this species to climate change:** *1 – 3 (1=low confidence; 3=high confidence)* 2
Comments:	

Figure 17. Example of completed extensive CVA adaptive capacity assessment. Image: NOAA

6.5.2 Limited Scope CVA

For a limited scope CVA, adaptive capacity is assessed using the adaptive capacity table (Figure 18). This table is split into two sections, intrinsic and extrinsic, which are scored separately. Column 1 of the adaptive capacity table lists a variety of factors that affect adaptive capacity. To balance the time-limited nature of a limited CVA with the reality that resource types have different factors that influence their adaptive capacity, the factors to be assessed are determined prior to the workshop (i.e., will be filled in for participants) but will differ between resource type (i.e., species, habitat, ecosystem service, heritage resource). For example, distribution, connectivity, and biodiversity are likely to be included in the assessment of a habitat's adaptive capacity but are not likely relevant to a maritime heritage resource. Similarly, the cultural value of an ecosystem service may be relevant to assessing its adaptive capacity but less-so for a species or habitat. Alternatively, some aspects of adaptive capacity, particularly extrinsic factors such as the flexibility of rules governing management, are likely to be applicable to the assessment of all resources. Despite these pre-determined differences, which can be explored in the example worksheets provided in Appendix A, the process that participants use for assessing adaptive capacity is the same for all resources.

Adaptive Capacity Table

Species (and hazard if applicable): **Timescale:**

Intrinsic Factors	**Adaptive Capacity**	**Rationale**
Extent, Distribution, & Connectivity		
Dispersal		
Phenotypic and Behavioral Plasticity		
Genetic Diversity		
Generalist/Specialist ranking		
Other:		
Other:		
Intrinsic Factor Average:		
Extrinsic Factors	**Adaptive Capacity**	**Rationale**
MPA Organizational Capacity	---	----
Staff Capacity (training, time)		
Responsiveness		
Community/Stakeholder Relationships		
Stability/Longevity of MPA		
Other:		
Management Potential	---	----
Existing Mandate		
Resource Value/Importance		
Monitoring & Evaluation Capacity		
Ability to Learn and Change		
Proactive Management		
Partner Relationships		
Science/Technical Support		
Other:		
Extrinsic Factor Average:		
Overall Adaptive Capacity (Average of Intrinsic and Extrinsic Factor Averages):		

Figure 18. Limited CVA species adaptive capacity table. See Appendix A for full worksheet. Image: NOAA

Each adaptive capacity factor can either be assessed once for each focal resource (i.e., the same across all climate hazards) or individually for each climate hazard (which is not done during an extensive scope CVA). The latter option is more time-intensive and requires a separate adaptive capacity table for each climate hazard. As such, this guidance document recommends assessing adaptive capacity once for each focal resource unless there is a compelling reason to do otherwise. However, if a compelling reason is raised during the assessment, it may be useful to allow participants to provide separate adaptive capacity scores for some hazards. Regardless of whether adaptive capacity is being assessed separately relative to each climate hazard, for each adaptive capacity factor participants assign a value between 1 (very low) and 5 (very high) and a confidence score of 1 (low) to 3 (high) in column 2 of the adaptive capacity table. If time allows, they can also record a rationale for their rating in column 3, which can be helpful for informing the report narrative and assessing adaptation actions (see Chapters 7 and 8). Once all factors have been assigned a score, participants calculate the average intrinsic and extrinsic adaptive capacity scores independently and record them in the appropriate cells of column 2. To find the final adaptive capacity score, participants take the average of these two summary scores. Determining the final adaptive capacity score in this way prevents undue weight being applied from either intrinsic or extrinsic adaptive capacity factors due only to the number of factors considered under each topic. This final score is recorded in column 7 of the primary table (Figure 9). If adaptive capacity was assessed independently for each climate hazard, this score is calculated for each hazard and recorded in the appropriate row of the primary table column 7. The overall adaptive capacity score for the resource is determined by taking the average of these scores (note that if adaptive capacity was not assessed independently for each hazard, the overall adaptive capacity score is the same as the final score obtained from taking the average of the intrinsic and extrinsic scores). An example of how adaptive capacity could be assessed can be found in Box 7c.

Box 7c: Assessing Adaptive Capacity During a Limited CVA – Coral Reef

Participants in the Shallow Coral Reef Habitat breakout group have finished assessing the sensitivity and exposure of the habitat to climate and non-climate hazards (Box 7a) and calculating the potential impact it is likely to experience over the next 25 years (Box 7b). It is now time for the group to assess the adaptive capacity of the shallow coral reef habitat, the final piece in determining the resource's vulnerability. To assess the habitat's adaptive capacity, the breakout group uses a habitat adaptive capacity table (Figure 19). The workshop organizers have instructed breakout groups to assess adaptive capacity once for each resource, rather than independently for each hazard. The workshop organizers have also pre-filled column 1 with habitat-relevant adaptive capacity factors that are both intrinsic, such as biodiversity and distribution, and extrinsic, such as policy flexibility and MPA staff capacity. The group uses their subject matter expertise and the background information presented during the workshop to assign an adaptive capacity score, and a confidence value in that score, to each factor. For example, the group determines that the shallow coral reefs in the MPA have shown a remarkable ability to recover from past extreme events and are relatively resistant to warming-induced bleaching, thus displaying exceptional evidence of past recovery and suggesting high intrinsic adaptive capacity to address these extreme events. Thus, the breakout group assigns a very high adaptive capacity value of 5 for past evidence of recovery and have medium (2) confidence in this value. In contrast, the group recognizes that the shallow reef habitat in the MPA is small and isolated from other reefs. Thus, they assign a low (2) adaptive capacity score for distribution and connectivity, a determination for which they have high confidence (3). After discussing and assigning values to all of the intrinsic adaptive capacity factors in the table, the group takes the average of these values to find that the overall intrinsic adaptive capacity of the habitat is high at a value of 4.2.

Adaptive Capacity Table

Habitat (and hazard if applicable): Shallow Coral Reef **Timescale:** 25 Years (2047)

Intrinsic Factors	Adaptive Capacity	Rationale
Extent, Distribution, & Connectivity	2 (3)	Reef is isolated
Recovery from Past Extremes	5 (2)	Strong recovery in the past
Physical Diversity	5 (3)	
Biodiversity	4 (2)	
Status of Key Species	5 (2)	
Other:		
Other:		
Intrinsic Factor Average:	4.2	

Extrinsic Factors	Adaptive Capacity	Rationale
MPA Organizational Capacity	---	----
Staff Capacity (training, time)	2 (2)	MPA is understaffed
Responsiveness	4 (2)	
Community/Stakeholder Relationships	4 (3)	
Stability/Longevity of MPA	5 (3)	
Other:		
Management Potential	---	----
Existing Mandate	5 (3)	
Resource Value/Importance	5 (3)	Reef is very important to community
Monitoring & Evaluation Capacity	4 (1)	
Ability to Learn and Change	5 (2)	
Proactive Management	5 (2)	
Partner Relationships	5 (2)	
Science/Technical Support	4 (1)	
Other:		
Extrinsic Factor Average:	4.4	

Overall Adaptive Capacity (Average of Intrinsic and Extrinsic Factor Averages):	4.3	

Figure 19. Example of completed limited CVA habitat adaptive capacity assessment. Image: NOAA

The group also assesses extrinsic adaptive capacity factors. The group recognizes that MPA staff are already overworked and under-resourced and thus staff capacity, which if high could increase extrinsic adaptive capacity, is low. Thus, they assign an adaptive capacity score of 2 to the extrinsic factor of staff capacity with medium (2) confidence. In contrast, they determine, with high confidence (3), that the habitat is very important to the culture and economy of the local community, which could increase the interest that the community has in maintaining the habitat and bring more resources to bear in order to do so. Thus, they assign a very high (5) adaptive capacity value to socioeconomic and cultural importance. After discussing and assigning values to all of the extrinsic adaptive capacity factors in the table, the group takes the average of these values to find that the overall extrinsic adaptive capacity of the habitat is high at a value of 4.4.

The group next takes the average of the overall intrinsic and extrinsic adaptive capacity values and determines that overall adaptive capacity of the shallow coral reef habitat is 4.3, which corresponds to a high adaptive capacity. As they did not assess independent adaptive capacities of the habitat for each hazard, this value also serves as the overall adaptive capacity. If they had determined independent adaptive capacities for each climate hazard, overall adaptive capacity would have been determined by taking the average of these independent values.

Adaptive Capacity: 4.3 (high)

6.6 Calculating Vulnerability

Calculating a resource's overall vulnerability is nearly the same for both CVA scopes. For both scopes, one approach involves using a matrix (Figure 20) with potential impact on one axis and adaptive capacity on the other. Participants find where these values intersect and this determines the vulnerability of the resource.

During an extensive CVA, both overall potential impact and adaptive capacity were previously calculated, so these values can be used to determine the overall vulnerability of the focal resource using the vulnerability matrix (Figure 20). An alternative option for calculating vulnerability during an extensive CVA is to use the equation: *Vulnerability = (Exposure + Sensitivity) - Adaptive Capacity*. While more time-consuming, calculating scores using this equation allows for more refined quantitative results with greater differentiation between final scores. These two methods rarely result in differing qualitative values of vulnerability (i.e., low vs medium), but can result in different quantitative values. Thus, it is important to decide which method will be used prior to the workshop and employ the same method across all breakout groups and for all resources.

Vulnerability					
	Potential Impact →				
Adaptive Capacity ↓	*Very Low (1)*	*Low (2)*	*Medium (3)*	*High (4)*	*Very High (5)*
Very Low (1)	Medium (3)	Medium (3)	High (4)	Very High (5)	Very High (5)
Low (2)	Low (2)	Medium (3)	High (4)	High (4)	Very High (5)
Medium (3)	Low (2)	Low (2)	Medium (3)	High (4)	High (4)
High (4)	Very Low (1)	Low (2)	Low (2)	Medium (3)	High (4)
Very High (5)	Very Low (1)	Very Low (1)	Low (2)	Medium (3)	Medium (3)

Figure 20. Matrix used to determine vulnerability from potential impact from and adaptive capacity. Image: NOAA

Using an equation rather than a table also allows for one or more components of vulnerability to be weighted more than the others, which can be useful if an MPA feels that one aspect of vulnerability is more or less important than another. For example, if an MPA feels that the assessments of sensitivity are particularly uncertain, they may choose to downweight sensitivity by multiplying it by some decimal. If weighting is used, it should be applied equally for all focal resources to ensure consistency, comparability, and ability to prioritize management. Further, any weighting should be justified in the methods section of the CVA report (see Chapter 8.6). While weighting can be useful, it should not be used lightly. Managers should discuss any potential weighting with workshop participants and fully consider the need to apply weighting before doing so, as it can drastically change the results of the assessment. It is also advisable to speak with others who have experience conducting CVAs before applying weighting to fully consider the benefits and drawbacks of doing so.

Box 6d: Calculating Vulnerability During an Extensive CVA – Bull Kelp

The participants in the bull kelp breakout group previously assessed the potential impact bull kelp is likely to experience as high (4) (Box 6b) and its adaptive capacity to be low (2) (Box 6c). Thus, they use the vulnerability matrix to find that this combination of potential impact and adaptive capacity results in bull kelp having a high (4) vulnerability (Figure 21). If the organizers had chosen to use the vulnerability equation, the group would have calculated a vulnerability score of 3.5 ([3+4]/2 = 3.5), which, when rounded, also results in bull kelp having a high vulnerability.

Vulnerability: 4 (high)

10. Vulnerability

Calculate the Vulnerability of the species using your values of Potential Impact (Box 6) and Adaptive Capacity (Box 9) using the table below:

Vulnerability

Potential Impact →

Adaptive Capacity ↓	*Very Low (1)*	*Low (2)*	*Medium (3)*	*High (4)*	*Very High (5)*
Very Low (1)	Medium (3)	Medium (3)	High (4)	Very High (5)	Very High (5)
Low (2)	Low (2)	Medium (3)	High (4)	High (4)	Very High (5)
Medium (3)	Low (2)	Low (2)	Medium (3)	High (4)	High (4)
High (4)	Very Low (1)	Low (2)	Low (2)	Medium (3)	High (4)
Very High (5)	Very Low (1)	Very Low (1)	Low (2)	Medium (3)	Medium (3)

Vulnerability: 4

Figure 21. Example of completed vulnerability determination for an extensive CVA. Image: NOAA

In a limited CVA, vulnerability is first calculated for each climate hazard independently in column 8 of the primary table using the potential impact (column 6) and adaptive capacity scores (column 7) that were previously determined (Figure 9). Overall vulnerability can then be calculated in two ways. The most straightforward is to take the average of the vulnerability scores calculated for each of the climate hazards in column 8. Alternatively, participants can use the overall potential impact and adaptive capacity scores that they calculated previously (see Chapters 6.4 and 6.5). These two methods rarely result in differing qualitative values of vulnerability (i.e., medium vs high), but can result in different quantitative values. Thus, it is important to decide which method will be used prior to the workshop and employ the same method across all breakout groups and for all resources.

Box 7d: Calculating Vulnerability During a Limited CVA – Coral Reef

The participants in the shallow coral reef habitat breakout group previously assessed the potential impact the habitat is likely to experience from each climate hazard (Box 7b) and that its adaptive capacity, regardless of climate hazard, is high (4.3). The group first uses the vulnerability matrix to calculate the habitat's vulnerability to each of the climate hazards independently. For example, the group previously assessed the potential impact that the habitat is likely to experience from ocean acidification to be medium (3). By using the vulnerability matrix, they find that the habitat's medium potential impact from ocean acidification, combined with its high (4.3) adaptive capacity, leads to a low (2) vulnerability to ocean acidification (Figure 22). They run the same analysis for the other climate hazards and determine that the habitat has a high (4) vulnerability to warming and low (2) vulnerability to changing storm patterns. As instructed by the organizers, the group takes the average of these three values to determine that the shallow coral reef habitat has a medium (2.6) vulnerability (Figure 23). They also note that if they would have used the high (3.7) overall potential impact that they calculated previously (Box 7b), in combination with the high (4.3) adaptive capacity value, they would have also concluded that the habitat had a medium vulnerability, but would have assigned it a value of 3 as a result of using the matrix. The result would have been the same if they had first used the overall sensitivity and exposure values to calculate overall potential impact, which would still have resulted in a high (4) potential impact (Box 7b).

Vulnerability: 2.6 (medium)

Vulnerability

Potential Impact →

Adaptive Capacity ↓	*Very Low (1)*	*Low (2)*	*Medium (3)*	*High (4)*	*Very High (5)*
Very Low (1)	Medium (3)	Medium (3)	High (4)	Very High (5)	Very High (5)
Low (2)	Low (2)	Medium (3)	High (4)	High (4)	Very High (5)
Medium (3)	Low (2)	Low (2)	Medium (3)	High (4)	High (4)
High (4)	Very Low (1)	Low (2)	Low (2)	Medium (3)	High (4)
Very High (5)	Very Low (1)	Very Low (1)	Low (2)	Medium (3)	Medium (3)

Figure 22. Example of completed vulnerability determination for a limited CVA. Image: NOAA

Primary Table

Habitat: Shallow Coral Reef **Timescale:** 25 Years (2047)

Climate hazard	Observed or projected direction and magnitude of change in hazard	Impacts of hazard on resource	Exposure	Sensitivity (from sensitivity table)	Potential Impact	Adaptive Capacity (adaptive capacity table)	Vulnerability (list key drivers)
Increased Water Temperature	Increase	Overall negative including increased bleaching and stress. Could increase disease	5 (High confidence)	5	5	4.3	4 Habitat is highly sensitive due to bleaching High adaptive capacity
Ocean Acidification	Increase	Decreased calcification, increased stress. Could lead to dissolution. Overall negative	3 (High confidence)	3	3	4.3	2 High adaptive capacity
Changes to Storm Frequency & Intensity	Increasing intensity, but fewer storms Projections are uncertain	Stronger storms could increase damage to coral. Fewer storms could benefit coral	2 (Low confidence)	4	3	4.3	2 High adaptive capacity Uncertain as to chnages in storms
		Average/Overall:	3.3	4	3.7	4.3	2.6

Figure 23. Example of a completed limited CVA habitat primary table including final vulnerability calculation. Image: NOAA

6.7 Determining Relative Vulnerability

A powerful application of a CVA is the ability to compare the assessed vulnerability of numerous resources of management concern. This allows managers to determine the relative vulnerability of resources, an important consideration when determining the relative urgency of management actions and the allocation of limited resources. The nature of the matrix approach used to assign a vulnerability score (see Chapter 6.6) can make determining relative vulnerability difficult as the single number produced (1-5) for each resource, particularly during an extensive scope CVA, can cloud differences. One solution to this challenge is to graph the vulnerability of resources.

This can be done in two dimensions by placing potential impact on one axis and adaptive capacity on another with the resource placed where these values intersect. When placing multiple resources on a single graph, this strategy can more fully separate the relative vulnerability of resources, even among those that have the same overall score. For example, a resource that has a potential impact score of 4 is assigned a vulnerability score of 4 if it has an adaptive capacity score of either 3 or 4. However, if graphed as described, it will have a higher *relative* vulnerability if it has an adaptive capacity score of 3 as compared to 4 (Figure 24). In addition to allowing for a more detailed exploration of relative vulnerability, graphing vulnerability in this way also makes it easier to determine which factors are affecting vulnerability, a crucial consideration when exploring management strategies.

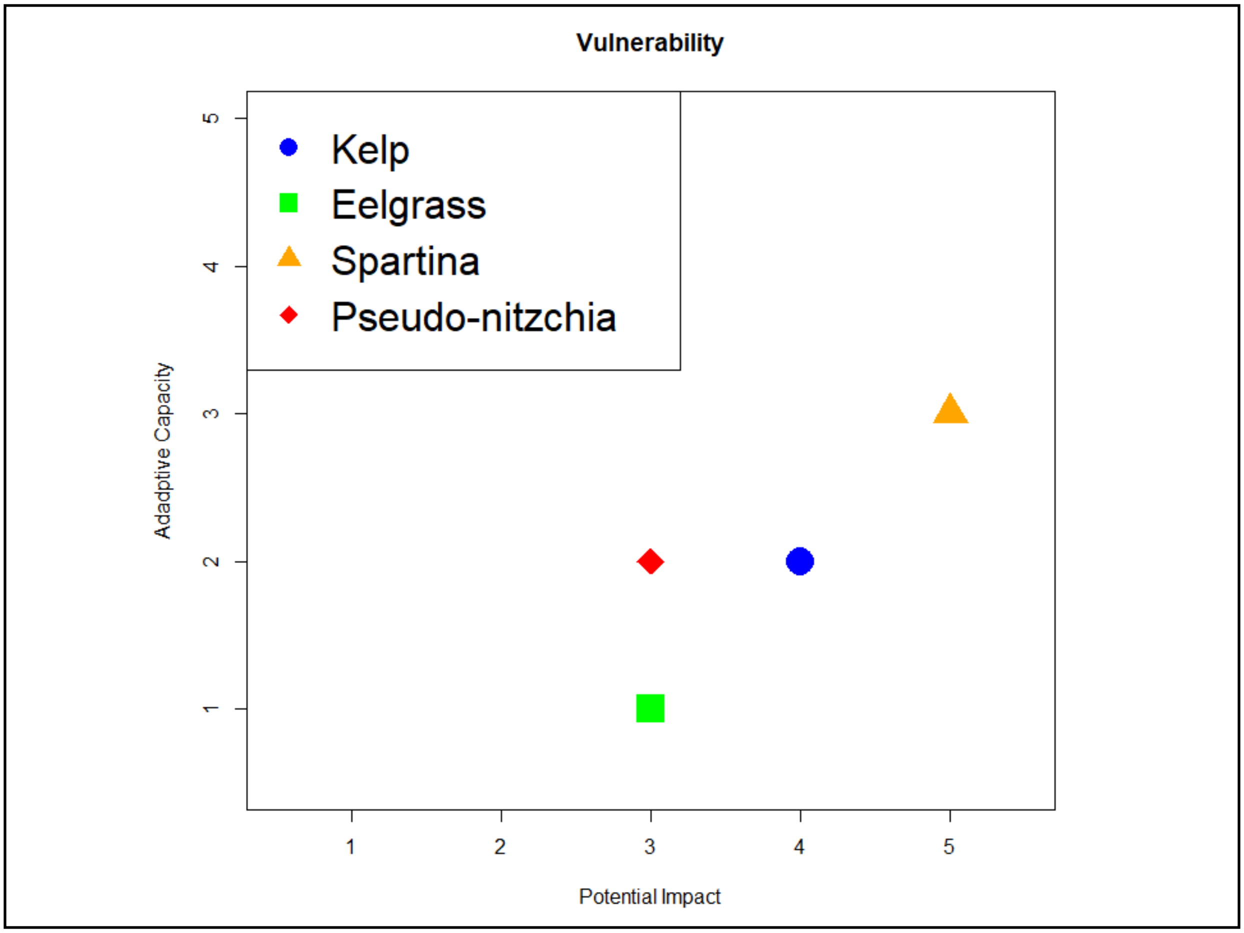

Figure 24. Example graphical representation of the relative vulnerability of four species which all have the same overall vulnerability score of 4 (high). Image: NOAA

Relative vulnerability can also be graphed in three dimensions by placing sensitivity, exposure, and adaptive capacity scores on the x, y, and z axes. While more complex and often requiring specialized software, this strategy can be particularly useful for quickly determining both relative vulnerability and the relative influences of sensitivity, exposure, and adaptive capacity in determining a resource's vulnerability. As such, this strategy can be very useful as a visualization when exploring management actions. If a three-dimensional figure is not possible, vulnerability can also be visually represented as a multi-dimensional variable with the dimensions representing its sensitivity, exposure, and adaptive capacity.

Another way to compare and assess relative vulnerability is through the use of a Venn diagram as developed by Foden et al (2013). This method uses the three components of vulnerability to categorize resources into one of four classes of vulnerability based on how the components overlap (Figure 25). Using this framework, a resource is considered to be Fres“sensitive” or “exposed” if the assessed scores for the respective component is high or very high (3.5 or greater if scoring quantitatively). The resource is considered to have low adaptive capacity if it has an assessed adaptive capacity that is low or very low (less than 2.5 if scoring quantitatively). A species that falls into two or more of these categories is considered to fall into one of the four classes of vulnerability. Those that are exposed, sensitive, and have low adaptive capacity are categorized as “highly vulnerable.” Such resources are at the greatest risk from climate change. Resources that are exposed and sensitive are categorized as “potential adapters” and may be at risk from climate change. Resources that are exposed and have low adaptive capacity, but are not sensitive, are categorized as “potential persisters” and may not be at risk, or at are lower risk than the previous categories, due to their relatively low sensitivity. Finally, those resources that are sensitive and have low adaptive capacity, but are not exposed are categorized as having “high latent risk” and, while not currently at risk, would become at risk from climate change if their exposure increased (Foden et al. 2013).

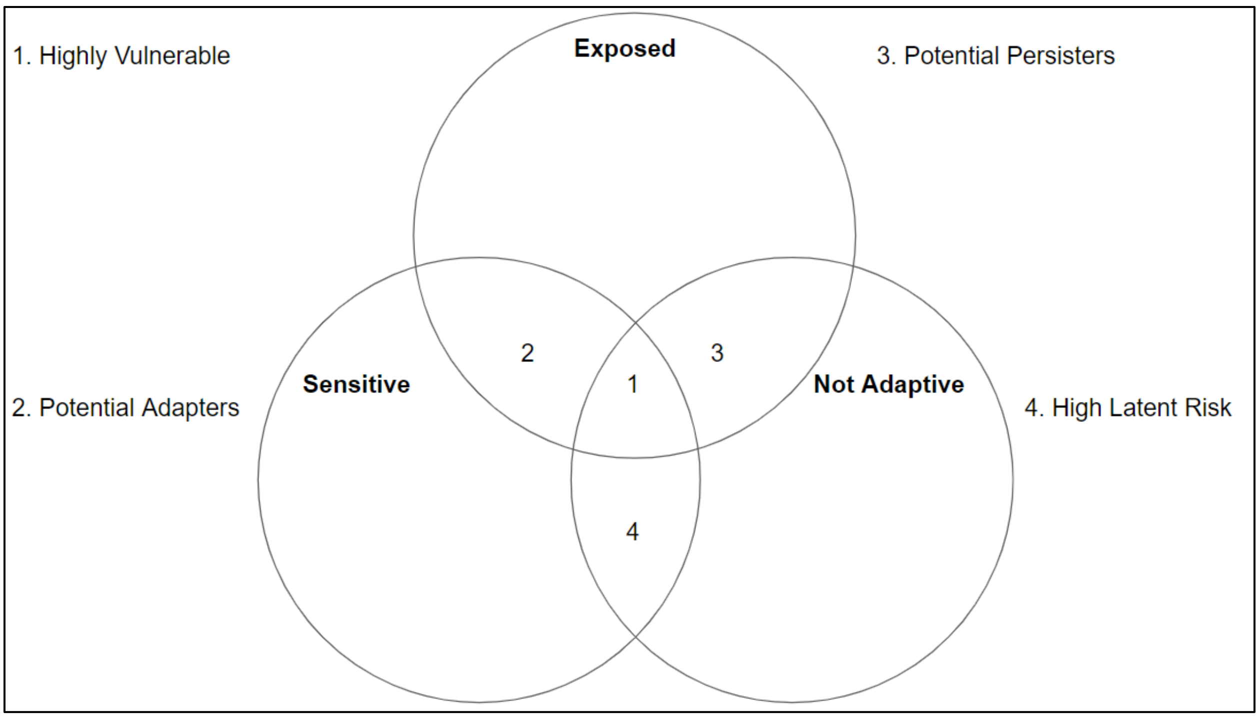

Figure 25. Venn diagram method for comparing and categorizing vulnerability. The four categories of vulnerability correspond to the numbers on the Venn diagram and are named within the figure. Category 1 corresponds to resources that are highly vulnerable. Category 2 corresponds to resources that are potential adapters. Category 3 corresponds to resources that are potential persisters. Category 4 corresponds to resources that have a high latent risk. Image: NOAA adapted from Foden et al. 2013.

The Venn diagram framework described above can be a useful way to explore vulnerability as it can help to compare the relative factors leading to the vulnerability scores of multiple resources. It can also be a useful framework for helping to prioritize and begin to develop adaptation actions (see Chapter 7). The relative vulnerability of resources within a vulnerability category can be further explored by combining the Venn diagram framework with either of the graphical comparisons described earlier in this section. For example, a 2-dimensional graph (Figure 24) could be created for each of the categories of vulnerability.

Each of the methods for comparing relative vulnerability described in this section provide useful and valuable information that can help to further inform management actions and prioritization. The precise method, or combination of methods that is best for a particular MPA will be determined by the type and level of information desired.

Chapter 7: Developing Adaptation Strategies

The primary reason for conducting a vulnerability assessment is to inform climate-smart management decision-making. Once a CVA is used to determine the vulnerability and relative vulnerability of MPA resources, a logical next step is to use that information to inform the development of adaptation strategies to address those vulnerabilities. Developing these strategies is an iterative process that often begins during the CVA workshop and extends through the writing of the CVA report and into other MPA planning and activities such as Management Plans. It is useful to set aside time at the end of the CVA workshop to begin brainstorming adaptation strategies with workshop participants, which often serves as a positive way to wrap up the workshop. This allows managers to leverage the expertise that have already been gathered for the CVA while the topic of vulnerability is at top of mind. Alternatively, if time is limited, the development of adaptation strategies can be reserved for the process of writing the CVA report and its subsequent review by CVA participants (see Chapter 8).

Regardless of how and when the results of the CVA are leveraged to inform the development of adaptation strategies, this process is the key touchstone between the CVA and intentional, actionable management for climate change. However, while the two processes interact, developing climate adaptation strategies is a field of expertise in and of itself independent of conducting a CVA. As such, rather than provide an exhaustive description of how to develop adaptation strategies, a topic about which much has already been written, this guidance will first describe how managers can begin this discussion during a CVA workshop and then briefly explore a number of adaptation management models while pointing to resources where managers can explore these models in greater depth.

7.1 What is Adaptation

Climate change adaptation means many different things to many different people and organizations. The Intergovernmental Panel on Climate Change (IPCC) defines climate change adaptation as “the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.” An interpretation more targeted at the needs of MPAs is “any policy or management action that is intended to allow resources, services, communities, or infrastructure to adjust to current or future changes in climate by reducing their vulnerability and/or increasing their resilience or adaptive capacity to the impacts of climate change.” Note that this description specifically incorporates the components of vulnerability, making it a particularly useful frame through which to apply the results of a CVA to inform the development of adaptation actions.

Many management actions fall under the definitions above. What makes such actions *climate* adaptation, rather than just adaptation, is the *intentional inclusion of adaptation to climate change hazards as a driving goal of the action*. Acting with such intentionality is important in climate change management. Fortunately, adaptation actions developed as a result of a CVA will almost by definition have been developed with the goal of addressing climate hazards.

It is equally important to understand what is not a climate adaptation action. Climate adaptation is often confused or confounded with climate mitigation which is "any policy or action that directly limits climate change and its effects" or, as defined by the IPCC "A human intervention to reduce the sources or enhance the sinks of greenhouse gasses." In essence, climate mitigation is inclusive of actions that reduce sources of greenhouse gas emissions or enhance greenhouse gas sinks. The inability of a management action to mitigate climate change does not preclude it from being an adaptation action. For example, restoring a coral reef with temperature tolerant corals does not reduce the sources or enhance the sinks of greenhouse gasses, and is thus not a climate mitigation action. However, it is a climate adaptation action as it increases the adaptive capacity of the coral reef to warming temperatures. A management action can also act as both a climate mitigation and a climate adaptation action. The restoration of a salt marsh, for example, has a mitigation benefit of enhancing a greenhouse gas sink (i.e., blue carbon) and an adaptation benefit of enhancing coastal resilience to sea level rise.

It is also important to understand how climate adaptation differs from climate assessment. Climate change assessment includes "any policy or action intended to better understand or monitor past, current, and future changing environmental conditions and their effects on resources, services, communities, and/or infrastructure." Assessment actions such as research, monitoring, and CVAs are often vital to inform adaptation and mitigation policy and action, but are not themselves adaptation or mitigation actions.

In a discussion of adaptation actions during, and even after, a CVA, mitigation and assessment actions are likely to be proposed and discussed. That should not be discouraged. Just because such actions do not fall strictly into the definition of adaptation does not make them less important. There is often a fine line between assessment, mitigation, and adaptation and all are critical components of the climate-informed management of MPAs. It is often the case that assessment and mitigation actions directly inform or enhance adaptation actions. The discussion of these actions may also spur further discussion that leads to innovative and important adaptation planning. Thus, while it is important to understand the difference between assessment, mitigation, and adaptation, the development of adaptation actions will often involve an interplay of all three.

7.2 Discussing Adaptation Actions During a CVA Workshop

It is often useful, although not strictly necessary, to set aside time during a CVA workshop to begin discussing adaptation actions that address the vulnerabilities uncovered during the workshop. In fact, workshop attendees often begin thinking about such actions whether they are prompted to or not. Leveraging the subject matter expertise that is already assembled as part of the CVA workshop is also an efficient use of time and leads to the discussion of adaptation actions that managers themselves might not have considered, or even actions that can be taken quickly. For example, participants in the Flower Garden Banks National Marine Sanctuary limited CVA identified invasive species, and particularly lionfish, as a non-climate stressor that increased the vulnerability of numerous habitats and species. One adaptation action that was proposed and discussed during an adaptation session of the CVA workshop was to permit the recreational harvest of lionfish in the sanctuary, which had not previously been permitted. As a result of this discussion, the sanctuary issued a permit to authorize staff of a recreational dive boat to conduct lionfish removals within sanctuary boundaries. This is an excellent example of how a vulnerability identified during a CVA, in combination with a discussion of adaptation actions, can lead to rapid, low-cost, no-regrets adaptation actions. Thus, this guidance highly recommends that managers set aside time at the end of the workshop to discuss adaptation actions with workshop participants.

A discussion of adaptation actions can take many forms, from a formal worksheet to an informal guided discussion, and can be as quick as a half hour or as expansive as a full day. Some ideas for worksheets that can help guide this discussion can be found in Appendix A. Regardless of the form such a discussion takes, it is useful to present an early set of CVA results to participants in order to inform the discussion. It can also be helpful to present some examples of potential adaptation actions and adaptation frameworks (see Chapter 7.3). This information is often best conveyed as a short presentation by either a workshop organizer or adaptation expert at the beginning of the discussion. The discussion of adaptation actions should also be free-flowing and open. This is a time where ideas should be encouraged regardless of their feasibility. The time for realism comes later in the planning process. Managers are often surprised how ideas that at first seem far-fetched can, upon further discussion and refinement, evolve into attainable, actionable, and important management actions and policies. Thus, the role of managers during this discussion is to listen, encourage, and record. Realism can be applied at a later stage of adaptation planning.

7.3 Adaptation Frameworks

When developing adaptation actions, it is useful to consider different approaches, or frameworks, to adaptation planning. These frameworks can help to inform and structure actions, often improving their chances of success and enhancing their impact. Many adaptation planning frameworks exist, but this section will cover only a few that NOAA's Office of National Marine Sanctuaries have found to be particularly useful in MPA climate adaptation planning. However, just because a framework is not included in this guidance document does not mean it is not useful or effective. The field of climate adaptation planning is broad and constantly expanding and refining. The frameworks presented here are intended to act as a starting point, not reflect a comprehensive representation of adaptation planning and actions. Further, these frameworks are not mutually exclusive. Many are interchangeable, interactive, and inclusive of each other. A successful adaptation action plan will often include actions that are informed by many or all of the below described frameworks. Perhaps of greatest importance, these frameworks are not prescriptive. Instead, they are intended to help managers and planners better frame and think about adaptation actions. No one framework is necessarily better than another. Managers should employ those that they are most comfortable with and best fit the climate management challenge at hand.

7.3.1 Reduce Vulnerability

The adaptation planning framework that is perhaps the most directly tied to a CVA is the "Reduce Vulnerability" framework. This framework focuses on actions that either increase a resource's adaptive capacity or reduce its sensitivity and/or exposure to climate hazards. In this way, adaptation actions developed using this framework seek to enhance climate adaptation by reducing a resource's vulnerability. The information obtained through a CVA can be used to directly inform adaptation actions by using this framework. For example, the breakout group assessing the vulnerability of bull kelp in chapter 6 (Boxes 6a-d) determined that bull kelp had high sensitivity and exposure to rising temperatures. An adaptation action that the group might propose would be to create artificial upwelling, which would bring cool deep water to the surface, at times when temperatures exceed a certain threshold. Such an action would decrease the exposure of bull kelp to warming and thus decrease its vulnerability. Alternatively, the group could propose the deployment of genetically engineered kelp that is more tolerant of warming, thus decreasing the sensitivity of the species and increasing the adaptive capacity of the population. While both of these adaptation actions could be prohibitive for their own reasons, they are good examples of early brainstorming that, at least in theory, could be viable adaptation actions. Further, these early ideas may be able to be refined into more palatable or achievable actions. Perhaps rather than genetically engineering bull kelp, managers could decide to introduce bull kelp from more southern populations which are already adapted to warmer conditions. Similar to the initial idea of genetic engineering, this action could introduce more warm-tolerant genotypes to the population thus increasing the adaptive capacity of bull kelp in the MPA and lowering its vulnerability to warming.

7.3.2 Resist-Accept-Direct

The "Resist-Accept-Direct" (RAD) framework was designed specifically to help managers make decisions in a climatological environment where change is inevitable and irreversible on human timescales. This framework helps managers understand the full range of possible decisions that can be taken in the face of inevitable and irreversible change from *Resisting* that change as long as possible, to *Accepting* that change and allowing it to occur, to *Directing* that change towards a preferred outcome. By encouraging managers to consider the full decision space, the RAD framework helps them make informed and purposeful choices.

As an example of the application of this framework, it can be imagined that a CVA reveals that water temperatures in an MPA will rise enough over the next 50 years to prevent the survival of the stony corals that form a coral reef. Managers can choose to Resist that change for as long as possible through actions such as shading or pumping cooled water through the reef. However, it is understood that at some point in the future, conditions will change enough that these actions will likely be insufficient to fully prevent the disappearance of the reef. As such, Resist actions are best taken to either buy time for the development of other adaptation actions, or when the resource being managed has sufficient significance (e.g., a world heritage site, unique, etc.) to warrant maintaining it in its current state as long as possible. Managers may also choose to Accept the change, allowing the reef to disappear over time. Accept actions are most often taken when an alternate state is preferable for some reason (e.g., mud flat becoming a mangrove forest), if the resource is not a high priority (e.g., a small beach among many), or if the cost of taking other actions is prohibitive when compared to the benefit. Finally, under this framework, managers could choose to Direct the change. Such actions are possible if there are multiple possible trajectories that the resource could take under change. Perhaps projections show that, under warming, the reef could either become dominated by algae, or by sponges and soft corals. In such a scenario, managers may choose to take actions to direct the change towards the sponge and soft coral reef as such a habitat provides for greater biodiversity and ecosystem services than an algae-dominated habitat.

The RAD framework recognizes that sometimes change is inevitable and managers will need to make difficult decisions. It was originally designed as a decision framework for addressing ecological change where climate-driven ecological tipping points result in the possibility of alternate stable states. However, in recent years, the framework has also been applied to social systems and ecosystem services (Smith et al. 2022). Further, the National Park Service has adopted this framework as central to its guidance for planning and managing resources under climate change. As such, the RAD framework shows potential as a flexible and useful tool to help managers both understand the full breadth of possible actions, and make difficult management decisions in an informed and purposeful manner.

7.3.3 Adapt-React-Cope

The "Adapt-React-Cope" framework describes how human communities and systems respond to external stressors and changing conditions, such as climate change. As such, this framework can be particularly useful in helping managers develop adaptation strategies related to ecosystem services and some cultural resources. It can also be a useful framing for managers when trying to understand and address external adaptive capacity factors.

The premise of the framework is that responses to external stressors or changing conditions can be categorized as either adapting, reacting, or coping behaviors (Green et al. 2021). An "adapting behavior" is one that involves "proactive planning of individual or collective actions based on knowledge of past or anticipated future environmental change" (Green et al. 2021). Essentially, an adapting behavior involves proactive planning and/or collective action. For example, if changing conditions cause a reduction in a primary fishery species, the community could proactively *adapt* by recognizing the problem and switching to new species that may be unaffected or new to the area before the historically harvested species declines to unsustainable numbers. A *reacting* behavior is "an unplanned response to a stressor or change" (Green et al. 2021) such as a government reacting to a climatologically-forced reduction in fishery species by closing the fishery. Finally, a *coping* behavior is one where a community passively accepts the consequences of an environmental change (Green et al. 2021) such as waiting for the fishery species to recover from the climatologically-forced decline.

This framework can appear to be more reactionary than the others discussed in this section as rather than providing a way to determine how to take action, it provides a tool to understand how a community has already responded. However, this framework is useful to adaptation planning as thinking through these various scenarios, particularly with respect to how communities might respond to changes to ecosystem services, can help managers more fully understand the consequences of change and potential adaptation actions and allow them to better address those consequences.

Chapter 8:
Writing a CVA Report

The final step in conducting a CVA is writing a CVA report. While this may at first seem to be a burdensome administrative task, the report is a critical component of the CVA. First and foremost, the report serves as an important reference document for managers and partners by collating all of the information from the CVA in one place. A well-written CVA report provides a wealth of information on resource vulnerabilities, the components of those vulnerabilities, and additional information from discussions during the workshop important to those vulnerabilities that may not be captured in the scores. As such, CVA reports are critical tools during the process of climate management and adaptation planning (see Chapters 7 and 9). Experience shows that a well-written report remains a valuable management resource for years after it is written. Greater Farallones National Marine Sanctuary, for example, continues to successfully reference and leverage its report when developing management actions nearly a decade after the CVA was conducted.

In addition to being a useful tool for managers, writing a CVA report is also important for providing transparency into an MPA's climate adaptation planning process. Communities, partners, and stakeholders deserve, and often have a legislatively-defined right, to understand the decision-making processes that govern the MPA and resources they depend on. The CVA report is an important component of that transparency as it describes the reasoning and process behind the CVA in addition to the supporting information leading to its final conclusions.

CVA reports can take many forms, from a 5-page brief description of results, to a lengthy and extensive document that includes introductory information and context. The form a CVA report takes is largely dependent on the needs of the MPA. A robust CVA report contains multiple sections, starting with an introduction of the MPA being assessed and the process of conducting a CVA and running through results and recommendations. The major components of a CVA report are explored briefly below. These sections can be reordered, split, or combined as best fits the needs of the MPA. Additional sections can also be included as deemed necessary by the writers and organizers of the CVA. There is no prescribed length for a CVA report. It should be as long as is necessary to convey the information produced during the CVA. While it is advisable to be as concise as possible, the author should also remember that this is the primary tool used to communicate the results of the CVA. Thus, if there is a piece of information that is important, it should be included, even if it lengthens the report. For this reason, CVA reports can become long documents (more than 100 pages for an extensive CVA). This length makes a concise, understandable executive summary critical to a successful report. However, CVA reports do not have to be cumbersome, lengthy documents. Results can be written up briefly with extensive references to other reports or references (such as this one) for CVA methods and process background. Thus, while this chapter describes the steps to writing a thorough, standalone report, many sections can be shortened, or even removed, with appropriate reference to other resources. Ultimately, *the length and format of the report should be driven by the needs of the MPA and its stakeholders*.

Even given the guidance provided below, the best way to learn how to write a CV report is to read those that have been published by other MPAs who have already completed the process.

Links to CVA reports completed by various national marine sanctuaries can be found in Appendix B.

8.1 Executive Summary

CVA reports can be quite long and detailed, especially for extensive CVAs. Thus, it is good practice to include an executive summary at the beginning of the report that briefly summarizes each of the sections included in the report and highlights key results. This summary should be no more than a few pages, and 1-2 pages if possible. The purpose of this section is to allow a reader to understand the key takeaways of the CVA in as concise and understandable a manner as possible while making it apparent where in the full report they can go to find more information on a topic that might be of interest. It is also important to recognize that this section is the most likely to be read by the widest audience. This reality along with the necessity of balancing brevity and completeness often make this section the most challenging and time consuming to write. Given that this section is a summary of the full report, it is best practice to write this section last.

8.2 Background – Introduction to the MPA/Site

It often useful to provide an introduction and background to the MPA or area being assessed. This includes information such as location, size of the site, key resources under the site's jurisdiction, and any other information that the author or site feels is relevant. Ultimately, this section is intended to set the stage for the reader and ensure that they understand basic information about the areas being assessed. Including a map of the MPA or area assessed is often useful as it can help quickly and easily orient the reader. If creating a short document, this background to the site could be achieved in a short paragraph largely through referencing or linking to other documents such as a website or site characterization document.

8.3 Background – Reasons for Conducting a CVA

This section helps the reader to understand why the CVA was conducted. This often includes both a history of the planning process that led to the CVA and a brief overview of the importance of climate adaptation planning and a CVA's place within it. As such, this section serves to further orient the reader and help them understand why managers decided to conduct a CVA, why CVAs are important, and the planning processes that led to this decision.

Explaining the process can be as simple as a straight-forward overview of the steps taken by the MPA leading up to the CVA. This can include any direction or mandate to undertake a CVA, such as a recommendation from an advisory body, a brief overview of partners consulted, and an explanation of how background information was gathered. While explaining this history can feel superfluous, it can be as short as a sentence or two and is important to provide transparency into the CVA process. It also helps the reader understand the motivations behind conducting a CVA.

It is useful to provide an overview of the importance of climate adaptation planning in order to orient the reader and ensure that they understand the importance of a CVA within the larger context of climate adaptation planning and management. At the very least, this should include information about what a CVA is, which can largely be achieved by referencing or adapting information from this or other resources (see Chapters 1-4), and how it fits into the site's climate planning process. For example, a national marine sanctuary might briefly detail their planning process by stating that the CVA was informed by, and took place after, a condition report, which uses information to assess how the state of resources have changed over the previous 5-10 years. They could then explain that this information about the past and current status and trends of resources was used to inform the CVA, which itself assesses future vulnerabilities, and that the information gained from the CVA will be used to inform management planning. In this way, a reader can clearly see how a CVA fits into the overall management planning process of an MPA. Ideally, the report would also briefly explain how the site plans to use the information from the CVA to inform sustained climate-smart management.

8.4 Background – Hazards Assessed

Providing background information on the past, current, and projected trends of the major climate hazards assessed in the CVA helps the reader to better understand not only which hazards were assessed, but why. This section often takes the form of an overview of the major climate hazards affecting, or anticipated to affect, the area of study. For a limited scope CVA, this section should cover every climate hazard assessed. For an extensive scope CVA, it should cover at least those climate hazards provided by the workshop organizers (see Chapter 4.3). Fortunately, much of this information was likely already developed as part of the preparation for the CVA (see Chapters 4.4 and 6.2), making it relatively easy to copy that information into the report or, if a public document was produced, reference. If there was another hazard that was included by participants during the workshop, the author may want to include an overview of that hazard if it was either assessed for multiple resources or was particularly influential in the assessment of one or more resources.

For each climate hazard, it is often useful to provide a brief overview of the past, current, and projected trends in that hazard for the area assessed. It can also be helpful to provide some information on the major impacts of the hazard. This information can help orient the reader as to why a particular hazard was assessed during the workshop. Each of these descriptions should be relatively short, generally a paragraph to a page. However, it is important to cite sources and useful to provide directions to resources where the reader can learn more about these hazards if they so desire. The bulk of the information for this section can generally be adapted or copied from the workshop background materials and the results of the pre-CVA background research (see Chapters 4 and 6.2).

While a CVA also assesses non-climate hazards, they are not always described explicitly in the report as the focus of the CVA is on climate change planning. If desired, the report can include a brief description of the major non-climate hazards assessed or reference other documents that may include information about non-climate hazards affecting the site (e.g., National Marine Sanctuary Condition Reports). At the very least, any non-climate hazards that greatly influence the assessment of a resource's vulnerability should be described when discussing the results of each resource.

8.5 Background – Resources Assessed

Describing the focal resources is critical to ensuring that the reader is fully oriented and understands the implications of the assessment. Depending on the intended audience and thoroughness of the report, this can take a number of forms from a list of resources, to more detailed descriptions. Information that may be useful to describe includes a resource's importance to the site, the status and any past trends in the resource's condition (this can often be accomplished by referencing other resources such a previously completed assessment like a sanctuary condition report), and any past impacts of climate hazards on the resource. It could also be useful to describe any special significance that the resource may have including particular legislative mandates and/or any ecological, cultural, and/or economic importance. This section can also describe any information that it is important for the reader to understand about the resource. For example, if the resource is inclusive of a group of resources (e.g., the resource assessed was "shipwrecks") or is representative of a larger set of resources (e.g., the resource assessed was one species of coral but is being used to represent a wider group of corals) this should be described.

Even relatively thorough descriptions are usually relatively concise, often a few paragraphs to a few pages. Resources that are more complex or inclusive of other resources (e.g., habitats) or are particularly important to the mission of the MPA, may warrant longer descriptions. Further, descriptions of different resource types (species, habitats, ecosystem services, cultural) are often grouped in sub-sections.

Some CVA reports will include the descriptions of the focal resources along with the results of that resource's assessment, rather than in a separate section. This can help organize the report in a manner that flows more naturally for the reader by allowing them to learn about a resource immediately before the assessment of its vulnerability. If the author chooses to describe the focal resources with the vulnerability results, they should still include a brief list of the resources assessed in the introductory/background material of the report.

8.6 Methods – Overview of Process

This section can be thought of as the "methods" section of the report. Here, the author should describe how the workshop was conducted. A best practice is to describe the methods in sufficient depth that another MPA could replicate the processes. As such, decisions such as how each of the components of vulnerability were calculated (e.g., as an average of the scores, through group consensus, or a mix; see Chapter 6.6), how focal resources were chosen (see Chapter 4.1), and how hazards were determined (i.e., pre-assigned or by participants; see Chapter 4.3) should be described in detail. Much of this methodological description could be accomplished by citing this guidance or other CVA reports where appropriate and describing where the process differed. A list of participants, or their expertise if they decline to have their name shared, should also be included as this helps the reader understand the breadth of expertise drawn upon during the assessment. Further, it is often useful to include a copy of the workshop agenda to ensure that the reader understands how resources were assessed (i.e., in what breakout group combinations). Providing examples of worksheets, either in this section or in an appendix, can also provide a useful resource to the reader. Much of this basic methodological information could be directly adapted from this guidance document.

Ultimately, every step of the workshop and assessment process should be described in this section. This helps to ensure that the processes that led to the results are repeatable and transparent. As CVA results inform management policy and action, this transparency is vital to ensure that communities and stakeholders have a sufficient understanding of how and why decisions are made.

8.7 Results

The results section is often the longest and most detailed section of the report. The assessed vulnerability, and components of vulnerability, should be described for each focal resource. While this can be presented using tables and/or figures, the report should also include a narrative for each resource that describes the assessment of that resource's vulnerability. This narrative should include information that cannot be gleaned from vulnerability scores alone but is nevertheless important to the development of management strategies. This includes the major hazards and factors that were assessed to affect each aspect of vulnerability and any relevant discussion related to the assessment of the resource. As such, this is the section of the report where relevant discussion from the workshop, including levels of confidence, are explored and explained. It is also useful to include any supporting resources, such as scientific sources, that support the resource's assessment. Such sources will often be provided by participants during the workshop or found in the process of developing background materials.

The organization of this section can take many forms, but the most common is as a series of individual vulnerability reports for each focal resource. Examples of this strategy can be found in the CVA reports from Greater Farallones National Marine Sanctuary (Extensive) and Gray's Reef National Marine Sanctuary (Limited), both of which are linked in Appendix B. This organization allows the reader to quickly find a resource that they are interested in and avoids confusion by focusing on one resource at a time. While this strategy is the most common, MPAs have also been successful communicating results in a more narrative form, such as in the Papahānaumokuākea Marine National Monument CVA report (Extensive, See Appendix B). Regardless of the style chosen to communicate results, it is important to ensure that a reader can fully understand the vulnerability of the resource and the components that led to that determination. Including cleaned-up versions of the worksheets as an appendix can be useful, but is not common practice.

In addition to information about the assessed vulnerability of individual resources, it can be useful to include some assessment of relative vulnerability. This is most easily communicated with a figure (see Chapter 6.7), but should also be accompanied by a narrative comparing the vulnerability of assessed resources. Communicating relative vulnerability is important as the funding and capacity available to take adaptation actions are often limited. Thus, while it would be ideal to address the vulnerabilities of all resources, difficult decisions often need to be made. Fully understanding the relative vulnerability of resources can both help make those decisions and provide support and transparency once decisions are made.

8.8 Results – Adaptation Strategies

This section of the report is often only included if a discussion on adaptation strategies was held during the workshop. If such a discussion was held, it is useful to use this section to include a summary of that discussion and highlight some of the adaptation options proposed. As an alternative, rather than describing adaptation actions in a separate section, actions discussed during the workshop for specific resources could be described along with the vulnerability results of those resources. Regardless of where in the report adaptation strategies are discussed, the author must be careful to avoid implying that managers are committing to pursue any of the actions described unless such a decision has been made prior to the publication of the report. However, describing the discussion of adaptation strategies is useful as it provides transparency into the planning process as well as a reference for managers during later adaptation planning.

8.9 Conclusions, Recommendations, and Next Steps

The final section of the report is often reserved for overarching conclusions, recommendations resulting from the CVA, and a description of any next steps planned by managers. This section serves as a location to explore overarching conclusions, discuss how the MPA plans to move forward, and provide any final thoughts on the CVA process or results. As such, it can vary greatly in length and detail depending on how information was covered in previous sections and the extent to which planning for next steps is undertaken prior to writing. At a minimum, this section should describe how the MPA plans to use the results of the CVA. This can be as simple as stating that the results will be used to inform climate adaptation planning or as complex as describing precisely how the results will inform specific adaptation actions. In general, it is best practice to provide as much information on next steps as is practical and known. While the author should not state or imply that actions will be taken that have not yet been approved, describing, to the best of their knowledge, how the CVA results will be used provides the reader with a more complete understanding of the importance of conducting a CVA and the significance of its results, as well as increased transparency into the climate adaptation planning process.

8.10 Review

After writing the report, it is important to send it to external experts, community members, and stakeholders for their review and feedback prior to publication. At the very least, all workshop participants should be asked to provide a review of the report, particularly any section covering the resources they assessed or for which they have expertise. It is also good practice to invite review from other subject matter experts, partners, communities, and stakeholders to ensure that there are no glaring exclusions or errors that may be missed by those who participated in the workshop. These external reviews serve the purpose of ensuring that the report is as accurate, clear, and complete as possible while also acting to provide an additional layer of transparency into the CVA process.

Chapter 9: Analyzing Results and Making the CVA Actionable

This section will explore the analyses and actions that should be taken immediately following, and in the months and years after conducting the CVA. After completing the CVA, it is important for MPA staff and managers to analyze the results and begin to take action to address identified vulnerabilities. Some early analyses will likely take place before, and may even be included in, the CVA report (see Chapter 8). However, much of the analysis and planning that results from a CVA occurs in conjunction with and after the writing of the CVA report. This analysis of results both informs and is informed by the CVA report. There is a balance between including as much information in the report as possible, making it concise and understandable, and publishing it in a timely fashion. As such, much of the process of analyzing CVA results and making them actionable takes place after, and in fact using, the report.

9.1 Organizing and Analyzing Results

The first step in analyzing a CVA is determining if there are any results that suggest immediate action needs to be taken, and initiating such actions. Actions that should be taken as soon as possible are usually easy to identify. These tend to be adaptation actions and management strategies that are identified as being particularly urgent or easily and immediately achieved. Actions that also address highly vulnerable resources are particularly ripe for implementation. For example, if a CVA found that a beach habitat was highly vulnerable to erosion and that an adaptation action that could reduce its vulnerability would be to close the use of a secondary, lightly-used employee parking lot, this may be an adaptation action that could be identified as a priority as it is easy, immediate, and low to no cost. However, if it was found that reducing the vulnerability of the beach required closing or moving the only access road to the MPA, addressing this vulnerability would likely need to be part of a longer, more deliberative planning process.

Developing a summary table can help managers understand and summarize CVA results and begin to identify priority adaptation actions (Figure 26). At a minimum, a CVA summary table should include each resource assessed, its vulnerability, and the hazards it was found to be vulnerable to; adaptation actions suggested for each resource; and each hazard assessed along with the state of knowledge relating to that hazard (i.e., current projections and trends as well as the source of that information). In addition, the table can also include information such as descriptions of assessed tipping points, impacts that could trigger adaptation actions or reassessment, and other information managers would find useful to guide adaptation planning. If the table is completed in time, it can be useful to include it in the CVA report (see Chapter 8). However, as summary tables are largely intended to be a tool to help managers organize results, prioritize actions, and plan for the future, their inclusion in the report is not always necessary. Even if a summary table is included in the report, it is useful to maintain a “living” version of the table that can be updated as new information becomes available.

Once completed, a summary table can provide a comprehensive picture of the vulnerability of assessed resources, the level of urgency created by different hazards, and a range

Resource	Vulnerability	Primary Factors Affecting Vulnerability	Suggested Adaptation Actions	State of Knowledge	Other Information
Kelp	High (4)	Warming, Storms, Generally low adaptive capacity	Introduce temperature resilient genotypes, Address extrinsic adaptive capacity concerns	Very good for impacts of climate change but limited for many biological factors	Would be useful to reassess despite good state of knowledge due to recent kelp loss
Eelgrass	High (4)	Warming, Increasing turbidity, Sea level rise	Introduce temperature resilience genotypes, Facilitate inshore migration	Generally limited for impacts of climate change	
Spartina	Low (2)	Sea level rise, Storms, High adaptive capacity	Facilitate inshore migration	Very good for sea level rise, relatively poor for other climate impacts	Would be useful to reassess if new information arises on other impacts
Ulva spp.	Very Low (1)	Warming, storms	Intertidal shading	Very poor for all climate impacts	High level of uncertainty in assessment
Surfgrass	Medium (3)	Warming, Sea Level Rise, Low Adaptive Capacity	Introduce temperature resilience genotypes, Facilitate inshore migration	Generally limited for impacts of climate change	
Crustose Coraline Algae (CCA)	Very High (5)	Ocean acidification, Warming, Very extrinsic adaptive capacity	No actions proposed were considered reasonable by the workshop participants	Very good for ocean acidification, generally poor for other impacts	

Figure 26. Example of a portion of a CVA summary table. Image: NOAA

of potential adaptation actions. In this way, the table can be a useful tool to assess the urgency and feasibility of a range of potential adaptation actions, helping to inform the allocation of limited resources. Further, by including summaries of the current state of knowledge, the table can be used to help managers understand when a hazard or resource may need to be reassessed. For example, if the current state of the knowledge suggests that a particular hazard is changing rapidly but future projections of level of change are uncertain, it may be beneficial to reassess resources that are particularly vulnerable to this hazard prior to a full CVA update (see Chapter 9.3). By providing information on the state of knowledge along with assessed vulnerability in one place, the summary table can be a useful tool to help make such decisions.

9.2 Applying Adaptive Management

While a CVA is often an early step, adaptive management is a cycle rather than a path. There is no beginning or end. Rather, each step informs the next and provides new information that eventually requires taking early steps again. This adaptive management cycle (Figure 27) can help inform and guide MPA management and adaptation planning. Similar to models of adaptation, there is an abundance of guidance on the implementation of adaptive management and the adaptive management cycle. Thus, while it is presented briefly here to demonstrate its relevance to the CVA process, this guidance document does not take a deep dive into adaptive management, but rather encourages the reader to seek out additional information if they wish to know more.

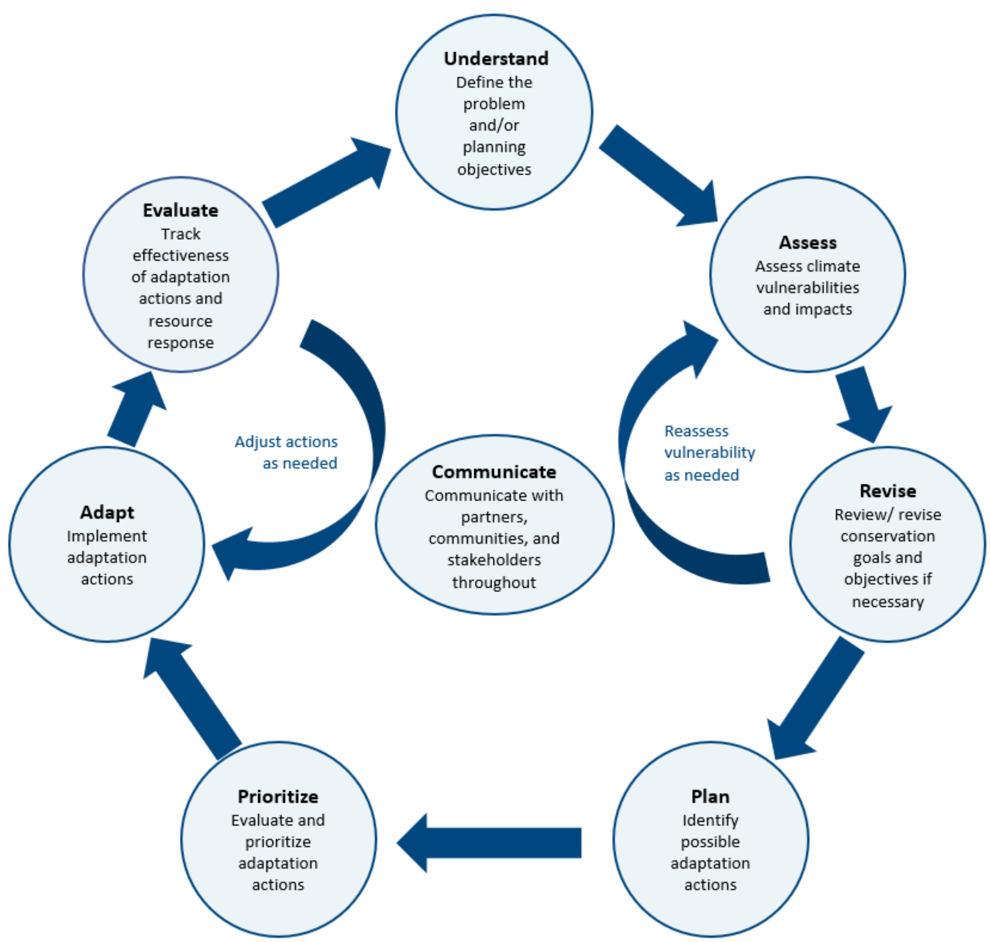

Figure 27. Adaptive management cycle. Image: NOAA

A CVA is often conducted as a part of the “assess vulnerabilities” or “understand” steps of the adaptive management cycle (Figure 28). In this way, the CVA informs the development and execution of adaptation strategies. As adaptive management continues to move along the cycle, monitoring and evaluating the effects of adaptation actions and continued climate change can lead to the need to reevaluate the conclusions reached from the CVA. Eventually, it will be necessary to update the CVA or even conduct a new CVA altogether. However, it is impractical to conduct a new CVA every time new information comes to light. Adaptive management allows managers to address some emerging threats, and leverage the information produced by a CVA to better understand the potential impacts of those threats, without the need to conduct a new CVA. Thus, this guidance strongly suggests that managers become familiar with the process of adaptive management and resources to do so are referenced in Appendix A.

9.3 Reassessing and Updating a CVA

Eventually, enough time will pass that a CVA will need to be updated, or even newly conducted, in order to continue to provide useful and useable information for management. There is no set rule for how often a CVA should be updated or revisited. In fact, the field of assessing the climate vulnerability of MPAs is new enough that few, if any, MPA CVAs have been updated or revisited. As a general rule, a CVA should be updated when the information is sufficiently out of date that it is no longer of practical use. The difficulty is that such a timeline can differ between resources and depend on trends in hazards and the state of knowledge. If the rate of change for a hazard, or the rate of change in the state of knowledge about that hazard, is rapid, the reassessment of resources that are particularly vulnerable to that hazard may need to be done more regularly than for resources that are vulnerable to hazards with a slow rate of change. Further, unexpected or extreme events could result in unexpected and rapid changes to the state of knowledge, or the condition of resources, and thus require a reassessment of vulnerability to inform management. For example, bull kelp was assessed as having low vulnerability to climate change during the 2014 Greater Farallones Vulnerability Assessment workshop. However, during the 2014-2016 Pacific Marine Heatwave, more than 90% of the MPA’s bull kelp disappeared and it has shown little to no recovery in the years since, signaling that it was more highly vulnerable to climate change, and warming in particular, than previously thought. This change in knowledge triggered a reassessment of bull kelp vulnerability and a series of adaptation actions. While this reassessment was not done through a formal updating of the MPA’s CVA, it could have been if managers felt that such a process would be informative.

To the knowledge of the authors, no MPAs that have employed the CVA methodology described in this guidance have updated or reassessed their CVA. However, Greater Farallones and Cordell Bank National Marine Sanctuaries are currently planning an update to the 2015 CVA to be completed in 2023. As this process develops and is executed, guidance will be provided in the ONMS Climate Vulnerability Assessment Toolkit, of which this guidance is one part.

References

Dudley, P. N., Rogers, T. L., Morales, M. M., Stoltz, A. D., Sheridan, C. J., Beulke, A. K., ... & Carr, M. H. (2021). A more comprehensive climate vulnerability assessment framework for fisheries social-ecological systems. *Frontiers in Marine Science, 8*, 674.

Farr, E. R., Johnson, M. R., Nelson, M. W., Hare, J. A., Morrison, W. E., Lettrich, M. D., ... & Stevenson, D. K. (2021). An assessment of marine, estuarine, and riverine habitat vulnerability to climate change in the Northeast US. *Plos one, 16*(12), e0260654.

Foden, W. B., Butchart, S. H., Stuart, S. N., Vié, J. C., Akçakaya, H. R., Angulo, A., ... & Mace, G. M. (2013). Identifying the world's most climate change vulnerable species: a systematic trait-based assessment of all birds, amphibians and corals. *PloS One, 8*(6), e65427.

Green, K. M., Selgrath, J. C., Frawley, T. H., Oestreich, W. K., Mansfield, E. J., Urteaga, J., ... & Crowder, L. B. (2021). How adaptive capacity shapes the Adapt, React, Cope response to climate impacts: insights from small-scale fisheries. *Climatic Change, 164*(1), 1-22.

Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. Climate Change Vulnerability Assessment for the North-central California Coast and Ocean. *Marine Sanctuaries Conservation Series ONMS-15-02*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp.

Metzger, M. J., & Schröter, D. (2006). Towards a spatially explicit and quantitative vulnerability assessment of environmental change in Europe. *Regional Environmental Change, 6*(4), 201-216.

Shein, K., J. Cavanaugh, H. Scalliet, S. Hutto, K. Roberson, B, Shortland, and L. Wenzel. 2019. Rapid vulnerability assessment for Gray's Reef National Marine Sanctuary. *National Marine Sanctuaries Conservation Series ONMS-1901*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 84 pp.

Smith, S. L., Cook, S., Golden, A., Iwane, M. A., Kleiber, D., Leong, K. M., ... & Wise, S. (2022). Review of adaptations of US Commercial Fisheries in response to the COVID-19 pandemic using the Resist-Accept-Direct (RAD) framework. *Fisheries Management and Ecology, 29*, 439–455

NATIONAL MARINE
SANCTUARIES

America's Underwater Treasures