North American Marine Protected Area Rapid Vulnerability Assessment Tool

This tool has three parts (a **user guide**, a set of blank **worksheets**, and a booklet containing **sample completed worksheets**) that are available as downloadable PDFs. The blank worksheets are in a dynamic PDF format so that users can easily fill, save and share their completed worksheets.

This tool is a product of the CEC's 2015-2016 project *Marine Protected Areas: Strengthening Management Effectiveness and Supporting Coastal Community Resilience*: **www.cec.org/our-work/ecosystems**

Commission for Environmental Cooperation

North American

Marine Protected Area

Rapid Vulnerability Assessment Tool

User Guide

Commission for Environmental Cooperation

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North American

Marine Protected Area

Rapid Vulnerability Assessment Tool

User Guide

Sources: CEC, Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

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Abstract

The North American Marine Protected Area Rapid Vulnerability Assessment Tool has three parts— a user guide, a set of blank worksheets, and a booklet containing sample completed worksheets. The User Guide and sample worksheets provide the narrative explanation of how to use the tool, while the blank worksheets are the hands-on component. Together, they comprise a tool that can help marine protected area managers conduct a rapid vulnerability assessment and adaptation strategy development process.

Executive Summary

The North American Marine Protected Area Rapid Vulnerability Assessment Tool was created to help marine protected area managers evaluate the implications of climate change for the habitats of their sites. Often, climate change is seen as a daunting challenge and as a result goes unaddressed. A rapid vulnerability assessment should allow managers to engage with the science of climate change as it pertains to their issues of concern (e.g., habitat management, species conservation, ecosystem services) in an easily understood manner, while also encouraging the creation of adaptation strategies to reduce the vulnerabilities identified. The longer-term goal of the tool and the process is that managers will be empowered to regularly consider the implications of climate change in their work, either by revisiting and reapplying the tool, or by applying the thought process it provides. Users will find the tool adaptable to uses beyond the habitat evaluation it was formatted for. With minor modification, it can be used to assess the vulnerability of any aspect of marine protected area management.

List of Abbreviations and Acronyms

CEC	Commission for Environmental Cooperation
ENSO	El Niño–Southern Oscillation
MPA	Marine Protected Area
OA	Ocean Acidification
PDO	Pacific Decadal Oscillation
RVA	Rapid Vulnerability Assessment
SLR	Sea Level Rise

Introduction

Though marine protected area (MPA) managers realize the immediate threat of climate change to the habitats and species they manage, resources are not always available to help managers fully integrate climate information and considerations into their management decisions. The North American Marine Protected Areas Rapid Vulnerability Assessment (RVA) tool was developed to make climate adaptation planning a simple, direct, and feasible process for MPA managers to undertake to better understand habitat vulnerability to climate impacts and the potential for climate-informed management to reduce vulnerability. The goal of this tool is to gather comparable information from MPA sites across the three North American countries and identify climate-informed management actions at both the site and seascape scale. Climate vulnerability assessments are an important tool for natural resource managers, as they provide insight into which resources are likely to be most affected by changing climate conditions, which informs priorities for management, and why these resources are likely to be vulnerable, which provides a basis for developing appropriate management responses (Glick et al. 2011, Brundell et al. 2011).

This user guide provides step-by-step instruction on the use of the RVA for MPA managers. This guide should be read in its entirety before participants begin using the RVA tool. The intended audience for the tool and this user guide are MPA managers that have a fairly extensive knowledge of habitats in their region, the quality of those habitats, the existing threats, and the regulatory and policy mechanisms that can be implemented to manage those habitats.

Many marine protected areas have worked extensively to characterize the condition of their natural resources, and that information not only greatly informs the RVA of the MPA, but is also complementary to the assessment. For example, the US National Marine Sanctuaries develop Condition Reports for individual sites and system-wide, to provide sanctuary managers with a snapshot of the pressures, current condition, and trends of selected sanctuary resources, including water quality, habitats, living resources and maritime resources (Gittings et al. 2013). Similarly, the North American Marine Protected Areas Network has developed a standardized ecological scorecard and accompanying condition report to help MPA managers characterize the current status and trends of water quality, habitat, and living resources within an MPA (Commission for Environmental Cooperation 2011). While condition reports are an incredibly useful tool to examine the cumulative effect of a number of non-climate stressors that determine a resource's condition, the RVA tool provides a more detailed look at how these non-climate stressors may interact with climate impacts to drive the condition of a resource. This tool serves to unpack the concept of climate vulnerability in the context of a habitat or resource's current condition and provide greater insight for MPA managers when planning for climate change.

Giant kelp (*Macrocystis pyrifera*).
California Channel Islands NMS

Claire Fackler, CINMS, NOAA.

How to use this tool

It is important to recognize that a RVA can be used at a variety of scales. In its initial use, it is suggested that a simple assessment be considered. Therefore, this RVA recommends an initial approach that considers no more than three habitat types, one timescale, three climate stresses, and three non-climate stressors. The MPA sites being evaluated are no doubt much more complex than this, however modification can be made in subsequent iterations to assess a greater variety of factors, a finer scale analysis or alternative features beyond habitat, such as species, management goals, or ecosystem services.

For an initial use, consider selecting the features for which you have the most knowledge and can therefore best learn the tool's approach, as well as the features for which you have the greatest concern.

Who to involve

While the RVA process can be undertaken by an individual manager to inform decisions at any level of decision making, the full benefit of the tool will be realized when it is used as part of a collaborative discussion between a field unit superintendent, other site managers, technical/scientific staff (internal or external), representatives of neighboring jurisdictions (e.g.,, indigenous territories, municipalities) and other interested stakeholders (e.g.,, businesses, community groups, conservation organizations). In this collaborative approach, the tool can be used to not only advise decisions but also to foster common understanding of climate-relevant science, support delegation of activities, and share knowledge between organizations. Preferably participants should have a breadth of knowledge regarding the habitat types being explored; however, if there are particular habitats (or species) of concern to the site, participants with expertise in those would be ideal. Participants must feel comfortable making assessments of their site based on the information they possess or can access during the process.

Prior to assembling a group to complete the assessment, it may be beneficial to have an initial discussion to determine the habitat types on which the assessment will focus. This will further assist users in determining who should participate and what additional resources might be useful to have at hand.

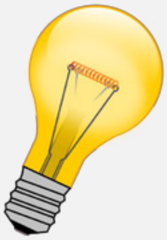
What you need to get started

The most important tools for completing this RVA are:

- an interest in learning how climate change is affecting the site being evaluated;
- knowledge of the site being evaluated (habitat types, basic ecological information, existing threats, management mechanisms);
- awareness of relevant climate impacts and access to basic climate information to support your understanding; and
- a day to spend applying that to the RVA tool.

Putting the tool to work

All worksheets used in this process have been compiled in a booklet. An example set of completed worksheets is also provided.



Tips and Lessons from the Field

First time through?

It is recommended that you choose no more than three habitat types, three climate related variables, three non-climate stressors, and one timescale.

Prioritizing or ranking your choices in each category and focusing on important management concerns first is helpful.

A RVA can reveal more questions than answers, but try to continue moving through the process. Note all information gaps and continue through the process by approximating where gaps have been identified. Approximations informed by experience and local knowledge are often sufficient for a first run-through. The relevance of gaps should be assessed and then addressed as needed before final conclusions are made.

Expand the process

Different timescales can lead to different vulnerabilities and adaptation strategies. Exploring connections or disconnections between vulnerabilities and strategies for different timescales is often useful.

If better suited to your management approach, substitute species, populations or ecosystem services for habitats.

Sometimes climate change alters ecological systems in beneficial ways from the perspective of a resource manager. If this is identified as a possibility while using the tool, make a note of the circumstance and explore it separately. However, don't forget to note positive interactions in the vulnerability assessment report.

This is your assessment

The most valuable assessment is one that you undertake and apply to your work. Therefore, as you use this tool you should feel free to customize it. If a category is missing, add it. If you are uncertain what is meant by one of the evaluation criteria, define it such that it resonates with your work.

Prepare your RVA

Before conducting your RVA process, ensure that participants share a common understanding of climate impacts in the MPA. This may require the development of a climate impacts summary that is shared with participants in advance or during the RVA process. This summary can be as simple as a one-page table or be a more in-depth literature review depending on needs and resources. A template for the simplest version of a climate impacts summary is provided in Appendix A.

Partner engagement

While not all partners may be able to participate in your RVA process, try to engage as many as possible. These should include MPA-based scientists and environmental groups, local and indigenous groups, and local, state and federal agencies with a stake in the managed areas. Invite those who cannot participate in the process to suggest focal topics (e.g. habitats, stresses), learn about the tool, and perhaps serve as a reviewer of the output products to share additional information or ideas.

Scientific accuracy

Following the RVA process, conduct a peer review process of findings and a literature review to ensure that results are accurate and reflect the current state of knowledge. The peer review process can include RVA participants as well as additional experts who might have specific knowledge needed to fill gaps or confirm analysis.

Step 1

Define the scope of the vulnerability assessment

Goal of this step: **Define the scope and initial parameters of the rapid vulnerability assessment you aim to undertake.**

Activity: **Identify habitats to consider, significant climate change related variables, relevant non-climate stressors, and the timescale in which you are interested.**

The scope-defining step is where a site manager selects the few but important initial parameters of the climate change RVA process. The tool requires the selection of habitats, climate change related variables, relevant non-climate stressors to your system, and the timescale to be considered in the assessment.

The RVA tool is structured to be scalable; however, for a first assessment it is recommended that you prioritize and focus on the top few components in each category. Think of your first use of the RVA tool as a learning process during which you become familiar with the tool, while beginning to explore the potential vulnerability of key ecological resources and what may be driving that vulnerability in order to develop adaptation strategies. With this successful initial orientation and first order vulnerability assessment, it is recommended that you return to the tool and complete the process again in a more specific manner, expanding on results, and diving deeper into those aspects that were identified as more important, all in support of implementing climate-informed adaptation strategies as part of your MPA management skillset.

The lists of habitats, climate change variables, and non-climate stressors presented in the RVA tool are intended to initially help identify reasonable ranges in scope for the process and were derived from resources in use by MPA managers (Commission for Environmental Cooperation 2011, Office of National Marine Sanctuaries 2010). It should be noted that the information and expertise needed to complete the RVA tool for your MPA will be dictated in part by the habitats, climate change related variables, non-climate stressors, and even timescale selected for the process. Consider your RVA team composition in concert with parameter selection.

Humpback whale (*Megaptera novaeangliae*).

Box 1. What habitat types are you considering for this assessment?

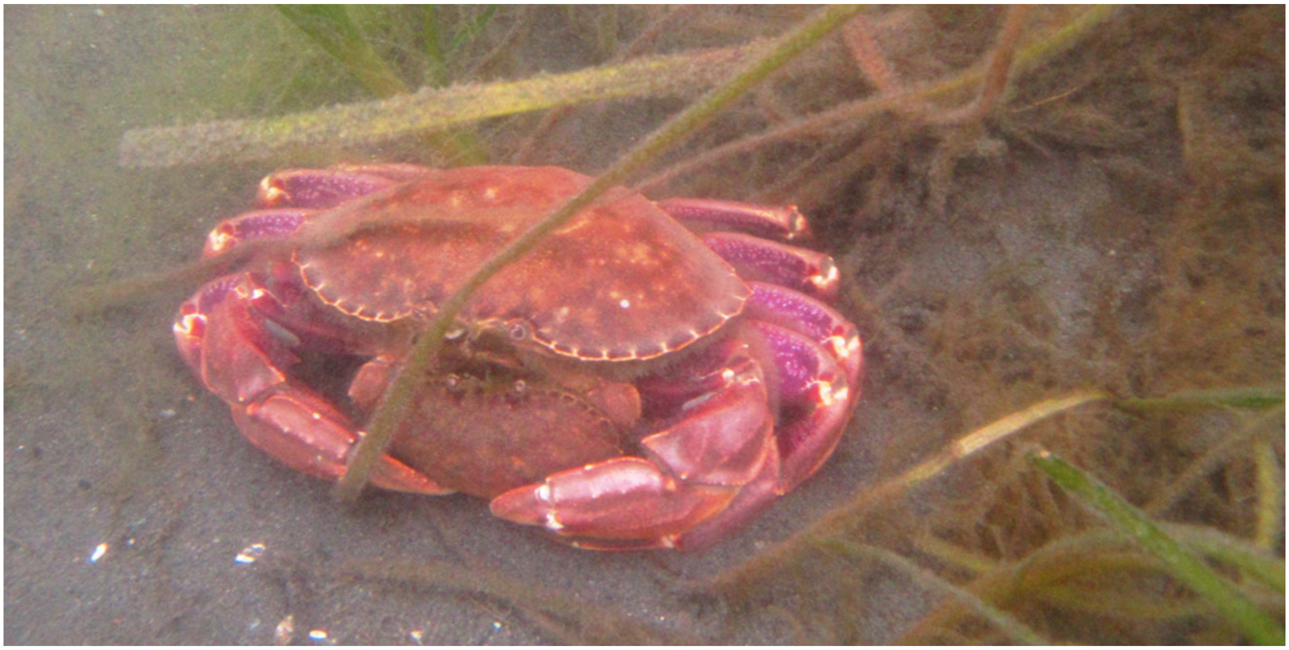
Select	Habitat Type
	Beach and dunes
	Cliffs and rocky shore
	Rocky intertidal
	Soft bottom intertidal and mudflats
	Estuary/wetland
	Pelagic
	Kelp forest
	Seagrass
	Coral reef
	Mangrove/Coastal Forest
	Deep seafloor, canyon
	Ice/Snow
	Other:

In Step 1, Box 1 of the worksheets, choose the habitat types that are at the top of your management concerns list. The listed habitat categories are hopefully similar to how you already think about your MPA. It may make sense to prioritize habitats already of management concern, including habitats that have species of importance for the MPA (i.e., iconic species), in order to better integrate climate change into existing management thinking. Or there may be a habitat or two which you think may be especially vulnerable to climate change. Assessing vulnerability is facilitated by having access to ecological information about the habitat, such as key species, population dynamics and movement, food web dependencies, species interactions, tipping points, and phenology. Of course each MPA will have many habitat types, so add habitats types as needed.

Box 2. What timescale are you interested in assessing?

Select	Timescale
	Near term (present to 10 years)
	Medium term (next 50 years)
	Long term (next 100 years)
	Very long term (> next 100 years)

Step 1, Box 2 of the worksheets is where you will indicate the timescale relevant to your management concerns for the habitats chosen. Choosing one timescale is recommended, and it is advisable to consider the timescale for which your MPA may be making decisions or management plans. Different timescales often rely on different data and assumptions. The timescale categories in Box 2 are broad but generally align with timescales commonly seen in climate change model results. Keep in mind that while the sophistication of climate change modeling continues to improve, reliability almost always decreases the farther into the future they are run.



Jennifer Yakimishyn

Red rock crab (*Cancer productus*) in sea grass, Pacific Rim National Park Reserve.

Box 3. What climate change variables are likely to affect these habitats?

In Step 1, Box 3 of the worksheets, you will choose the climate change related variables to be considered. Include the significant climate change related variables that are connected to each of the three habitats already chosen or the variables that concern you. Hopefully data are available that identify recent past and future trends in these variables. Monitoring data or specific modeling efforts may have identified trends and can provide insights into future conditions. Climate change data for a few variables are widely available at different spatial and time scales through a handful of clearinghouses listed in Appendix B. It is helpful to think about relevant spatial scales and time scales when looking for useful climate change data. However, avoid falling into the trap of trying to find the perfect data set. Use what you have or can find easily for the RVA. The climate related variables listed in Box 3 are relevant to marine and nearshore ecosystems, but are not exhaustive, so add others as needed.

Habitat			Climate Stress
			Increased water temperature
			Sea level rise
			Diminish dissolved oxygen
			Altered currents
			Altered upwelling/mixing
			Altered precipitation patterns
			Ocean acidification
			Turbidity
			Wave action/coastal erosion
			Salinity
			Storm severity/frequency
			Harmful algal blooms
			ENSO/PDO
			Other:

Box 4. What non-climate stressors currently affect these habitats?

Assessing climate vulnerability requires an understanding of local stressors, how climate change may influence these stressors, and an exploration of how local stressors and climate change stresses may interact. A rapid approach is limited in ability to explore the complexity of these interactions, but it is important to identify them. Often it is the interaction of climate and existing non-climate stressors that will lead to significant vulnerabilities. Step 1, Box 4 lists a few non-climate stressors that are common in marine and nearshore systems, but add others as needed or already identified. Local non-climate stressors have often already been identified in management planning.

If this list does not include a non-climate stressor that is in evidence at your site, use the "Other" line to add it to your assessment. It is not essential that your definition of any of these stressors matches that of other users, so feel free to personalize this list and define the stressors so that they resonate with your site.

Habitat			Non-climate Stressor
			Land-source nutrient pollution
			Land-source non-nutrient pollution
			Marine-source pollution and spills
			Development/population growth
			Harvest
			Aquaculture
			Invasive species
			Disease
			Tourism/Recreation
			Transport
			Extraction (mining, oil & gas)
			Energy production
			Overwater/underwater structures
			Roads/armoring
			Dredging
			Boat groundings
			Noise
			Researcher disturbance
			Altered sediment transport
			Other:

Step 2

Construct the assessment matrices

Goal of this step: **Set priorities for your vulnerability assessment and explore the vulnerability assessment components.**

Activity: **Transfer the information from Step 1 onto the worksheets you will employ to complete the vulnerability assessment.**

Using the results of Step 1, create a separate set of worksheets (Tables 1-3) for each habitat type you plan to assess. The content you need to transfer includes:

- Habitat type and Timescale: Insert this in the top of Table 1, as well as the location (MPA or other site) for which the assessment is being undertaken.
- Climate Stress: Insert selected stresses into Table 1 Column A, Table 2 Column D and, if you choose to evaluate the habitat for each stressor separately, into Table 3 Column C under Habitat.
- Non-climate Stressor: Insert selected stressors into Table 2 Column A.

National Ocean Service Image Gallery

Olympic Coast National Marine Sanctuary.

Step 3
Undertake the assessment

Goal of this step: **Apply your local knowledge to consider the implications of climate change for your site by habitat.**

Activity: **Describe and evaluate how climate and non-climate stressors will affect your site's vulnerability.**

This section is the heart of the rapid vulnerability assessment. Thoughtfully completing worksheet Tables 1, 2 and 3 provides a rapid overview of the key components of vulnerability at your site by habitat. In addition to the step-by-step instructions provided in this section, the RVAT Worksheets include a version of the completed worksheets as an example.

In **Table 1: Vulnerability Assessment**, for each of the climate stresses that you entered in Column A, complete Column B by considering how climate change has been observed or is projected to manifest. Include the direction and magnitude of the change for the timescale you have selected for this assessment. Also include a description of any specific details you have about how this climate stress may manifest in your region. This description is based on available information, including personal knowledge and/or formal assessments.

Table 1. Vulnerability Assessment

Location:		Habitat Type:				Timescale:	
A Climate Stress	**B Indicate the observed or projected direction and magnitude of this stress, as well as any specific relevant details**	**C Anticipated effects on this habitat type** (Highlight any important features that might be affected)	**D Likelihood**	**E Consequence** (Table 2)	**F Risk** (Figure A)	**G Adaptive Capacity** (Table 3)	**H Vulnerability Level (Figure B) & Key Drivers**

In Column B, and in every other appropriate location on these worksheets, be sure to include notes on the source of any data or other information that informed your answers. Please list formal citations, websites and/or personal communications.

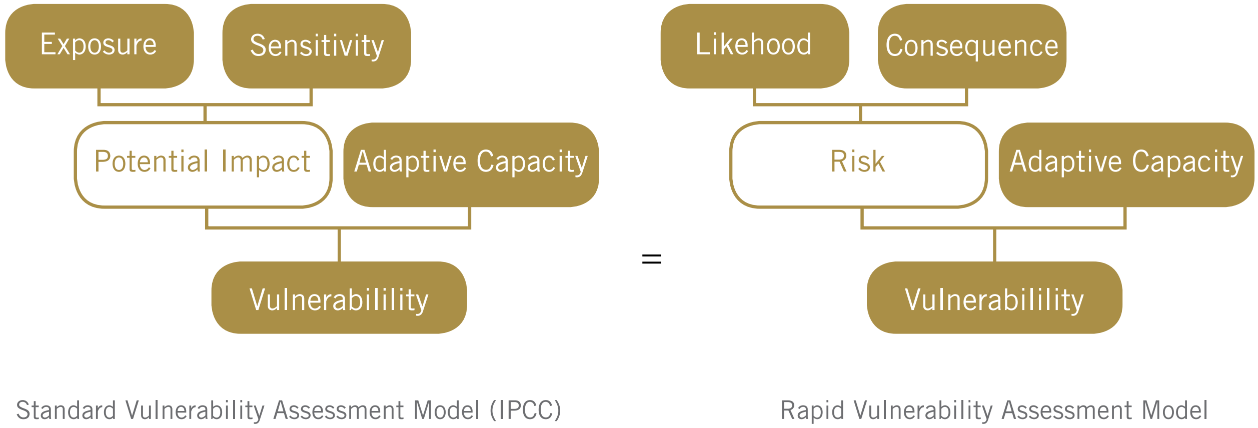
In Column C, consider the changes described in Column B and describe how this will affect the habitat type being assessed. List physical and biological effects anticipated based on projected climate change.

In Column D, given all the information you know, assign the likelihood of the anticipated effects on the habitat described in Columns C occurring in the chosen timescale. This evaluation is based on available information, including personal knowledge and/or formal assessments. In doing this you are considering certainty based on your knowledge of the evidence and consensus of the interpretation of this evidence. Use the following scale:

Almost certain (>50% probability)	**Likely** (50/50 probability)	**Possible** (less than 50% but not unlikely)	**Unlikely** (probability low but not zero)	**Rare** (probability very low, close to zero)

Likelihood can be considered analogous to exposure in the standard vulnerability assessment model (Figure 1).

Figure 1. Vulnerability assessment models compared



Prior to completing Column E, complete Table 2: Consequences.

In Table 2, using the non-climate stressors that you entered in Column A, complete Column B by considering how each stressor is currently or has historically affected this habitat type. Also include descriptions of any actions currently taken to address the effects of each stressor. In your answers, you should explore synergistic interactions between climate and non-climate stressors.

Table 2. Consequences

Location:	Habitat Type:		Timescale:		
Ⓐ Non-climate stressor	Ⓑ How does this stressor affect this habitat type?	Ⓒ Will climate change make this better or worse? (+/-)	Ⓓ What is the combined impact of this non-climate stress and... [Insert your three climate stresses here]		
Consequence: Assess the consequence of the direct effect of the climate stress in tandem with existing non-climate stressors on this habitat type. (Negligible, Minor, Moderate, Major, Catastrophic)					

In Column C, based on your local knowledge of these non-climate stressors and the current and anticipated effects of climate change, designate whether climate change will make the effect of the non-climate stressor better/less problematic (+), worse/more problematic (-). If you believe there will be no interactive effect, indicate this (nil).

In Column D, considering the three climate stresses that you entered in the header row, describe the combined impact in each subsequent row of the non-climate stressor with each climate stress. In Column D you should also describe if there are interactions between multiple non-climate stressors in conjunction with one or more climate stresses. For example, if the presence and persistence of invasive species will be affected by increasing water temperature in conjunction with ocean acidification, or the impact of fisheries harvest will be affected by invasive species and increasing water temperature, describe those interactions in the space provided.

In the final row of Column D, assign the degree of consequence in this habitat type of the direct effect of climate change stress combined with the effects of these non-climate stressors. This evaluation is based on available information, including personal knowledge and/or formal assessments, using the following scale:

Catastrophic	Major	Moderate	Minor	Negligible
(Habitat will cease to exist or have its function permanently altered.)	(Key species or functions may be dramatically altered, such that value is undermined.)	(Species numbers may decline, function may be diminished, such that habitat is seen as degraded but still present.)	(Habitat will continue to function but activities such as recovery will be impaired.)	(Habitat and its key components will not be visibly or functionally affected.)

Transfer these consequence values from Table 2 to the respective rows in Column E of Table 1.

CONANP

CONANP staff doing cleaning and maintenance of coral nursery. Acropora cervicornis colonies at National Park Costa Occidental de Isla Mujeres, Punta Cancún y Punta Nizuc.

Consequence can be considered analogous to sensitivity in the standard vulnerability assessment model (see Figure 1).

In Table 1 Column F, use Figure 2 below (Figure A of the Worksheets) to determine the level of risk by combining the likelihood and consequences levels assigned to each climate stress for this habitat type.

Figure 2. Risk = Likelihood x Consequences

Likelihood	Consequences				
	Negligible	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Low	Low
Unlikely	Low	Low	Moderate	Moderate	Moderate
Possible	Low	Moderate	Moderate	High	High
Likely	Low	Moderate	High	High	Extreme
Almost certain	Low	Moderate	High	Extreme	Extreme

Prior to completing Column G, complete Table 3: Adaptive Capacity Assessment of Habitat.

In Table 3 the adaptive capacity of the habitat (ecological potential) and of the institutions that manage the habitat (social potential) are evaluated based on available information, including personal knowledge and/or formal assessments. In most cases, adaptive capacity will be the same across climate stresses, however in a few cases it is possible that it will vary, therefore separate sections have been provided in Column C under Habitat to assess each of those stresses independently.

Table 3: Adaptive Capacity Assessment of Habitat

	Ⓒ Assess status and condition of each factor of Adaptive Capacity for this habitat. Rate on a scale from 1-5 (5=Superior, 4=Good, 3=Fair, 2=Poor, 1=Critical) [If your answers vary by stressor, consider evaluating the habitat for each stressor separately.]	
Ⓐ Ecological Potential	**Habitat (and stressor if applicable):**	**Rationale:**
Extent, Distribution & Connectivity		
Past Evidence of Recovery		
Value/Importance		
Physical Diversity		
Biodiversity		
Keystone & Indicators Species		
Other:		
Ecological Potential Average		
Ⓑ Social Potential		
Organization Capacity		
Staff Capacity (training, time)		
Responsiveness		
Stakeholder Relationships		
Stability/Longevity		
Other:		
Management Potential		
Existing Mandate		
Monitoring & Evaluation Capacity		
Ability to Learn and Change		
Proactive Management		
Partner Relationships		
Science/Technical Support		
Other:		
Social Potential Average		
Combined Potential Average		
Adaptive Capacity		

Convert average to adaptive capacity rating: Low = 1 – 2.3; Moderate = 2.4 – 3.6; High = 3.7 – 5

Assess the condition of each ecological factor and the status of each social factor using the following scale:

5	4	3	2	1
Superior	**Good**	**Fair**	**Poor**	**Critical**
(This factor exemplifies the ideal condition)	(This factor does a better than adequate job but could use improvement)	(This factor is adequate but could be easily improved)	(This factor is not adequate, but it provides modest function)	(This factor is not functional or does not exist)

Definitions of ecological and social potential factors and customization options for Table 3 are provided in pp. 14-15 below.

To help in the evaluation of the **ecological potential** factors of adaptive capacity, consider the following explanation of each factor. Keep in mind that you do not need to evaluate a factor that does not apply to your practice, and that you can add a more relevant factor to evaluate in the "Other" line.

Extent, distribution & connectivity: Habitats that are currently widespread in their geographic extent, with high integrity and continuity likely have greater adaptive capacity, and may be more likely to withstand non-climate and climate stresses and persist into the future. Habitats that are degraded, isolated, limited in extent, or currently declining due to non-climate and climate stresses likely have less adaptive capacity, and may be less likely to persist into the future.

Past evidence of recovery: Some habitats may have more rapid regeneration times and/or are dominated by species with short generation times. Habitats with a shorter recovery period from the impacts of stressors (<20 years) may have greater inherent ecological adaptive capacities than slower developing/recovering habitats (>20 years), as slower recovering habitats may be more inherently vulnerable to the potential intervening effects of climate change.

Value/importance: Is the habitat highly valued ecologically or societally? Habitats with a high societal value likely have higher adaptive capacity, as people may have a greater interest in protecting and/or maintaining them and the ecosystem services they provide. Habitats may be ranked as having high ecological value due to greater compositional heterogeneity/variability, or as a result of their high value they may benefit from greater conservation prioritization, either of which could confer greater adaptive capacity.

Physical diversity: Habitats that include diverse physical and topographical characteristics (e.g.,, variety of aspects, sediment types) may have higher adaptive capacity. Also known as heterogeneity, this could be a site with a more varied depth profile, complex currents, north and south facing habitat, or many other variable physical features that could confer adaptive advantage.

Biodiversity: The level of diversity of component species and functional groups in a habitat may affect the adaptive capacity of that habitat to climate change impacts. For example, habitats with multiple species per functional group likely have greater adaptive capacity because response to changes in climate varies among the species. Greater biodiversity in terms of variety and number of component species and functional groups may increase potential adaptive capacity for a given habitat at a given location.

Keystone and indicator species: A habitat may include populations of important species, whether protected, endangered, or ecologically critical. The adaptive capacity of these species should be evaluated on your assessment of their condition. Habitats where keystone and indicator species are in better condition may have greater adaptive capacity.

To help in the evaluation of the **social potential** factors of adaptive capacity, consider the following explanation of each factor. Keep in mind that you do not need to evaluate a factor that does not apply to your practice, and that you can add a more relevant factor to evaluate in the "Other" line.

Staff capacity (training, time): It is useful to consider the diversity of expertise, the understanding and confidence in addressing climate change challenges, and the institution's ability to be flexible and accommodate additional management responsibility and effort. Few resource management professionals have been trained in climate science and adaptation. Adaptive capacity can be greater if you have staff with the right professional training and the time to apply it.

Responsiveness: The ability of an organization to adjust its management and structure may be necessary in responding to climate change. In some cases, this could be a dramatic shift, such as changing a sites management strategies from restoration to retreat for a habitat type. Does your management structure allow you to stop taking action and accept the loss of a once-protected resource? In other cases, responsiveness may be more subtle, such as changing the timing of actions, including seasonal or temporary closures during periods of high stress.

Stakeholder relationships: Many adaptation actions will require changes in management. In some cases, this will require stakeholder buy-in or action. Having good stakeholder relationships can enhance adaptive capacity.

Stability/longevity: Organizations that have short planning horizons, short governance structures or lack long-term commitment will have less adaptive capacity as there may not be any ability to follow through on needed actions.

Existing mandate: If management mandate does not exist for the habitat or it cannot be interpreted to include climate change planning, adaptive capacity is diminished.

Monitoring and evaluation capacity: Even if you have the ability to implement actions, if you cannot measure its efficacy through monitoring and evaluation procedures you will not be able to know if it is effective or if it needs modification to improve outcomes. Adaptive capacity is enhanced when monitoring and evaluation are part of management practice.

Ability to learn and change: Having a culture or structure that allows for modification of management actions as new information is acquired is vital to effective adaptation. Often referred to as adaptive management, organizations where this is common practice will have a higher adaptive capacity.

Proactive management: Often adaptation actions will need to be put into practice before a problem becomes evident. For example, planning for range shifts of species of concern may require changes in species management or habitat restoration before a species arrives at a new location. If proactive management can be practiced, adaptive capacity will be enhanced.

Partner relationships: When adaptation actions require transboundary or interagency cooperation it is essential to have strong partner relationships. Partners will need to have a common understanding of climate projections, vulnerabilities, and adaptation options. In cases where partner relationships are strong, adaptive capacity may be greater owing to the ability to work collaboratively and flexibly to make management changes as needed.

Science/technology support: Climate science advances daily. Having access to science partners or in-house science expertise is essential for maintaining a sufficient awareness of current understanding of processes to make informed management decisions. Adaptive capacity will be improved when science and technology support are available.

At the end of each section (ecological and social) calculate the average for the column. Then, in second row from the bottom, calculate the combined average of these two sections. Use that average value to determine adaptive capacity based on the scale below.

Another option is to not combine the averages for these two sections so that adaptive capacity of ecological potential and social potential can be considered separately. In that case, each cell in Table 1 Column H can be divided so that vulnerability level is expressed considering ecological potential and social potential separately. This is just one example of how the tool can be customized to fit your preferred approach.

3.7 to 5	2.4 to 3.6	1 to 2.3
High	Moderate	Low

Transfer these adaptive capacity values from Table 3 to the respective rows in Column G of Table 1.

In Figure 3 below (Figure B of the Worksheets), combine risk and adaptive capacity to determine vulnerability level. Transfer this vulnerability level to the respective rows in Column H of Table 1, and add the key drivers of this vulnerability. To identify the key drivers of your calculated vulnerability, consider the factors that were used to calculate this vulnerability level (likelihood, consequence and adaptive capacity) and the model presented in Figure 1.

Figure 3. Vulnerability = Risk x Adaptive Capacity

	Adaptive Capacity		
Risk	Low	Moderate	High
Low	Low	Low	Low
Moderate	Moderate	Moderate	Low
High	High	Moderate	Moderate
Extreme	High	High	Moderate

Remember that, for each climate stress, Risk = Likelihood x Consequences.

If likelihood or consequence is:

- **High** then it is playing a role in increasing vulnerability, and there is opportunity to reduce whichever is high in order to develop adaptation strategies.
- **Low**, then it may not play a role in increasing vulnerability, and likelihood may not be reducible through adaptation strategies.
- **Moderate**, then it might be playing a role in vulnerability, especially if it may interact with another factor. There may be an opportunity to reduce likelihood or consequence in order to develop adaptation strategies.

If adaptive capacity is:

- **Low**, then it is playing a role in increasing vulnerability, and increasing adaptive capacity is an opportunity when developing adaptation strategies.
- **High**, then it may not play a role in increasing vulnerability, and there may be no opportunities to increase adaptive capacity as an adaptation strategy.
- **Moderate**, then it might be playing a role in vulnerability, and increasing adaptive capacity may provide an opportunity to develop adaptation strategies.

  If there is a need to work on adaptive capacity, it will be important to go back to Table 3 and assess whether ecological, social or a combination of both potentials, are at cause in order to target adaptation strategies effectively.

For those rows in Table 1 that indicate High or Moderate vulnerability, work to develop adaptation strategies to reduce these vulnerabilities in Step 4.

Step 4
Adaptation strategy development

Goal of this step: **Generate and evaluate adaptation strategies and implementation**

Activity: **Based on the vulnerabilities identified, develop management responses to reduce those vulnerabilities, and explore implementation considerations.**

Once the issues relating to High and Moderate vulnerability are identified, it is time to begin considering what, as MPA managers, you can do to reduce those vulnerabilities. By considering the climate stresses of concern and the factors of the habitat that are the key drivers of the vulnerability (likelihood, consequence and adaptive capacity), adaptation strategies can be developed.

Begin by transferring the climate stress and the key driver(s) of that vulnerability description from Table 1 to Table 4, Column A. With your knowledge of the system and the management opportunities, consider what could be done to reduce these vulnerabilities. At least one strategy should be developed for each vulnerability and recorded in Column B. After creating a suite of strategies, proceed to Columns C and D to evaluate their relative cost and expected efficacy.

Table 4: Strategy Development

Ⓐ Vulnerability	Ⓑ Strategies	Ⓒ Cost (H/M/L)	Ⓓ Cost (H/M/L)

For cost, estimate if this strategy would be Low, Medium or High in cost. You can choose to do this relative to existing management budgets or to the value of the resource. For efficacy, consider if the strategy is likely to reduce the vulnerability and help you achieve your desired goal. Again, use a Low, Medium and High scale. Clearly low cost, high efficacy strategies are preferable and may become a priority, whereas high cost, low efficacy strategies would be best avoided. Further prioritization of actions can be made based on the intermediate hierarchy created by these rankings.

For many, the idea of developing adaptation strategies can be daunting as most have had little formal training in this area. There are a few resources that can help, including: CEC Guide for Planners and Managers to Design Resilient Marine Protected Area Networks in a Changing Climate (Commission for Environmental Cooperation 2012), Greater Farallones National Marine Sanctuary Climate-Smart Adaptation Report (Hutto 2016) and Coastal and Marine Adaptation Strategies and Actions (Reynier and Hansen 2015).

There are many ways to develop adaptation strategies; here are two techniques that can help.

Vulnerability Assessment Model: By drawing directly from the results of a vulnerability assessment, this method considers strategies that will reduce likelihood (or exposure), reduce consequence (or sensitivity) and/or increase adaptive capacity for any given climate stress and any given habitat. Some examples of strategies in each of these categories as developed in the Greater Farallones National Marine Sanctuary Climate-Smart Adaptation Report (Hutto 2016) are presented in Figure 4.

Figure 4. Sample Adaptation Strategies for the Vulnerability Assessment Model

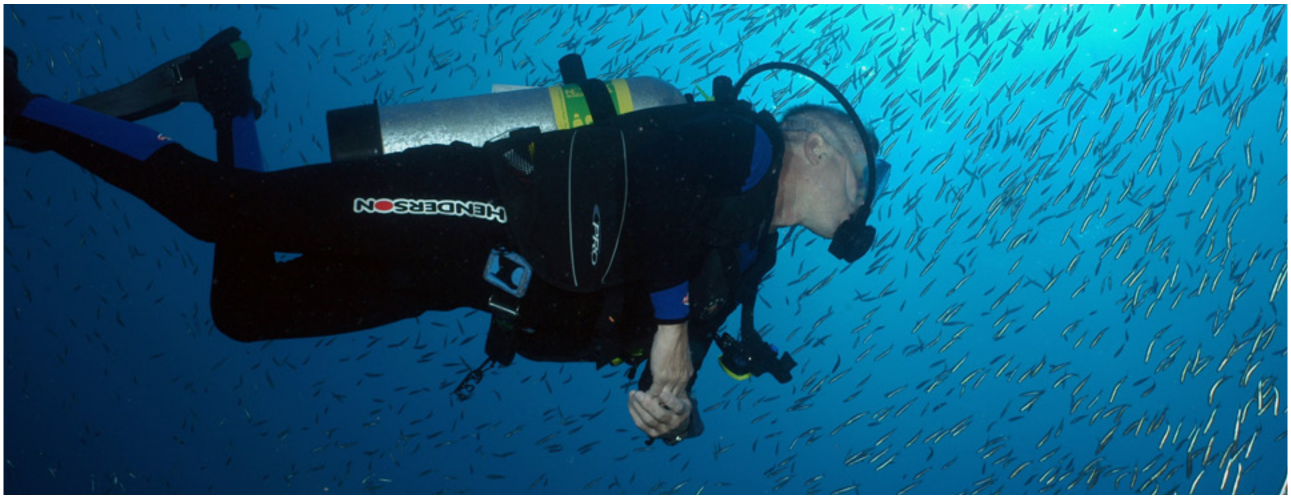
Stress/Vulnerability	Sea Level Rise Strategies for Estuaries
Reduce likelihood/exposure	Add or relocate sediment to areas that are sediment-starved in estuaries and wetlands to keep pace with sea level rise.
Reduce consequence /sensitivity	Identify demonstration sites within vulnerable estuaries for implementation of green infrastructure projects and living shorelines techniques.
Increase adaptive capacity	Identify and purchase lands behind vulnerable estuaries to allow for landward migration of habitat in response to sea level rise.

The 3 Rs: An alternative approach is to consider the different types of response to adaptation, categorized as resistance, resilience and response. Resistance strategies are those that maintain current conditions by holding back change. Resilience strategies recognize that there is change happening and provide opportunity for the system to adjust in response, so that function is maintained at the site being managed. Response strategies recognize that historic functions may no longer be possible at a given site without dramatic change or movement to a new location. Often these strategies can be thought of as a continuum wherein early actions are often aligned with resistance, followed by resilience and response as time progresses. Additionally, this suite of options may be adopted across a site in response to variable local conditions and goals.

While these are similar to the outcomes from the Vulnerability Assessment Model approach, often this framing is easier for practitioners to envision and apply. Examples from Reynier and Hansen (2015) are presented in Figure 5.

Figure 5. Sample Adaptation Strategies for the 3 Rs

Stress/Vulnerability	Sea Level Rise
Resistance	Use “soft-engineering” techniques and/or natural infrastructure to replenish or mimic natural buffers (e.g. restore tidal marsh for coastal protection).
Resilience	Require setbacks and buffers from the shoreline for all future development.
Response	Maintain and/or increase habitat connectivity to facilitate species migrations (e.g. update marine zoning to ensure reef connectivity)



G.P. Schmahl, Sanctuary Superintendent. NOAA/NOS/NMS/FGBNMS; National Marine Sanctuaries Media Library.

A scuba diver swims amid a school of fish. Flower Garden Banks National Marine Sanctuary.

After identifying the priority adaptation strategies, it will be necessary to plan their implementation. Table 5 provides an opportunity to identify various aspects of implementation to encourage action be taken as a result of the RVA process.

Table 5: Strategy Implementation

Ⓐ Strategy	Ⓑ Leader and potential partners	Ⓒ Monitoring and evaluation criteria	Ⓓ Funding/ Costs	Ⓔ Existing or needed management mechanisms	Ⓕ Timeline

Transfer priority strategies from Table 4 to Table 5 Column A. For each strategy, complete Columns B through F with enough detail that partners would be able to help with implementation.

Column B: Leader and potential partners - Who would be responsible for this strategy? Who would they need to actually make it happen? These can be specific individuals, positions or organizations. Provide whatever level of detail is appropriate for this strategy.

Column C: Monitoring and evaluation criteria - How would you know if this strategy was having the desired effect (e.g., actually reducing the vulnerability that was identified)? Include the parameter to be measured, how it will be measured and what you would expect to see if the strategy was effective.

Column D: Funding/Costs - Is funding needed? Can existing funding be repurposed? Is there a likely source of funding that will need to be approached? Are there other funding costs associated with the strategy?

Column E: Existing or needed management mechanisms - Does the mandate to enact the strategy exist? Would policy need to change? Would something need to be managed that is currently not managed?

Column F: Timeline - When will this strategy begin? How long will it take?

Step 5
Create your own narrative vulnerability assessment report

Goal of this step: **Help internalize and communicate your plan.**

Activity: **Transfer the results of the table to a narrative format to more easily share your plan.**

The RVA worksheets can give you a great deal of information, but it is a useful step to convert these analyses into a narrative form both to allow you deeper exploration of the findings and to create a more accessible product for partners.

Vulnerability assessments are often very long, including detailed explanation of the supporting evidence provided by climate science, ecological analysis, site monitoring and modeling. However in the RVA process the product will be more succinct with reference to supporting material, rather than inclusion.

The shortest version is a Vulnerability Statement. This can be useful in helping you think through your process, although it is unlikely to be used as a standalone product. A sample is provided in the RVAT Worksheets.

A longer version would be a Vulnerability Assessment Report with the following sections:

- Introduction to the site (including habitat types present, existing non-climate stressors, management approach)
- Reason for vulnerability assessment
- Key climate stresses experienced and anticipated
- Projected impact of climate change on each habitat type, including interactive effects with non-climate stressors
- Table identifying likelihood (exposure), consequence (sensitivity) and adaptive capacity from the RVA process
- Possible adaptation strategies (that were identified as higher priority based on cost and efficacy), including brief descriptions of implementation parameters.
- List of resources used to complete the vulnerability assessment.

Guadalupe fur seal pup (*Arctocephalus townsendi*), Guadalupe Island Biosphere Reserve.

Erendira Valle

Appendix A

Climate Change Impacts Summary Template

Parameter	Change to date	Direction and range of projected change	Trends in projected change	Confidence	Map
Water temperature					
Sea level rise					
Dissolved oxygen					
Currents					
Upwelling/mixing					
Precipitation					
Ocean acidification					
Turbidity					
Wave action/ coastal erosion					
Salinity					
Storm severity/frequency					
Harmful algal blooms					
ENSO/PDO					
Other					

For all content, include footnotes or other **attribution of sources** in order to simplify subsequent review or citation in the vulnerability assessment.

Invite RVA participants to assist in completion of cells for which you do not have readily available information.

Change to date: Any changes that have already occurred in this parameter at your site. If there are no data with respect to change from historic condition, briefly synopsize the current condition (e.g. current average annual water temperature at the site is….).

Direction and range of projected change: Anticipated changes in this parameter at your site. Include timeframe associated with described projection (e.g. water temperature will increase between 1.5 and 5°C by 2050).

Trends in projected change: Simplify the projection to indicate the big patterns relevant to management (e.g. increasing water temperatures will continue over the next century, with greatest warming in summer months, exacerbated by increasingly common cessation of upwelling).

Confidence: The level of confidence of the projected change (e.g. High, 95%, very likely).

Map: Use this column to refer to any associated maps or graphics that can be available for RVA participants.

Example:

Parameter	Change to date	Direction and range of projected change	Trends in projected change	Confidence	Map
Sea level rise	Regionally has increased by 15 cm over the past 100 years (California Energy Commission 2006), with local tide gauge monitoring (NOAA) showing ~20 cm over past 100 years.	2050: 12 – 61 cm 2100: 42 – 167 cm (National Research Council 2012)	↑, may increase toward the higher end of this range owing to some uncertainty	Very high	Not available

Chubs (*Kyphosus bigibbus*) in foreground and goatfish (*Mulloidichthys sp.*) in distance. Northwest Hawaiian Islands

Appendix B
Resources

Marine Protected Area Vulnerability Assessments

Bezuijen, M. R., C. Morgan, and R.J. Mather. 2011. *A Rapid Vulnerability Assessment of Coastal Habitats and Selected Species to Climate Risks in Chanthaburi and Trat (Thailand), Koh Kong and Kampot (Cambodia), and Kien Giang, Ben Tre, Soc Trang and Can Gio (Vietnam)*. Gland, Switzerland: IUCN.

Dia Ibrahima, M. 2012. *Vulnerability Assessment of Central Coast Senegal (Saloum) and The Gambia Marine Coast and Estuary to Climate Change Induced Effects*. Coastal Resources Center and WWF-WAMPO, University of Rhode Island.

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

Pendleton, E.A., J.A. Barras, S.J. Williams, and D.C. Twichell. 2010. *Coastal Vulnerability Assessment of the Northern Gulf of Mexico to Sea-Level Rise and Coastal Change*. U.S. Geological Survey Open-File Report 2010-1146.

Pereira R., C.I. Donatti, R. Nijbroek, E. Pidgeon, and L. Hannah. 2013. *Climate change vulnerability assessment of the Discovery Coast and Abrolhos Shelf, Brazil*. Conservation International.

Climate Adaptation Knowledge Exchange (CAKE): Find more examples of vulnerability assessments and adaptation resources relevant to your work on CAKE (www.CAKEx.org) and the Climate Registry for the Assessment of Vulnerability (www.CRAVe.CAKEx.org).

General adaptation

Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment

A guide developed by the National Wildlife Federation and partners for resources managers to help assess climate change impacts on species and ecosystems and ways to safeguard them. It is designed to assist fish and wildlife managers and conservation and resource professionals to better plan, execute, and interpret climate change vulnerability assessments.

Glick, P., B.A. Stein, and N.A. Edelson (ed.). 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. Washington, DC: National Wildlife Federation.

Climate Savvy: Adapting Conservation and Resource Management to a Changing World

Climate Savvy considers the implications of climate change for key resource management issues of our time—invasive species, corridors and connectivity, ecological restoration, pollution, and many others. How will strategies need to change to facilitate adaptation to a new climate regime? What steps can we take to promote resilience? Climate Savvy offers a wide-ranging exploration and practical steps of how scientists, managers, and policymakers can use the challenge of climate change as an opportunity to build a more holistic and effective philosophy.

Hansen, L.J. and J.R. Hoffman. 2010. *Climate Savvy: Adapting Conservation and Resource Management to a Changing World*. Washington DC: Island Press.

Guide for Planners and Managers to Design Resilient Marine Protected Area Networks in a Changing Climate

This guide was created to assist in leveraging the unique features of marine protected area networks to increase resilience in the face of climate change.

Commission for Environmental Cooperation. 2001. *Guide for Planners and Managers to Design Resilient Marine Protected Area Networks in a Changing Climate*. Montreal, QC: Commission for Environmental Cooperation.

Monitoring climate effects in temperate marine ecosystems

This monitoring framework was developed to supplement MPA monitoring with climate change monitoring in temperate regions in order to track climate change effects on habitats and species, understand the effects on MPA performance and evaluate climate change adaptation measures. It can be used to develop monitoring and evaluation tools for adaptation strategies in MPAs.

MPA Monitoring Enterprise. 2012. *Monitoring climate effects in temperate marine ecosystems*. Prepared by EcoAdapt. Oakland, CA: California Ocean Science Trust.

A Reef Manager's Guide to Coral Bleaching

The Reef Manager's Guide provides information on the causes and consequences of coral bleaching, and management strategies to help local and regional reef managers reduce this threat to coral reef ecosystems.

Marshall P.A., H.Z. Schuttenberg, H.Z., J. West, R. Berkelmans, D. Bizot, B. Causey, H. Cesar, L. Ming Chou, C. Hawkins, O. Hoegh-Guldberg, J. Hoey, M. McField, N. Marshall, J. Maynard, P. Mumby, D. Obura, R. Salm, N. Setiasih, S. Walsh, G. Aeby, K. Anthoney, R. Aronson, R. Arthur, A. Baird, R. Buddemeier, S. Coles, N. Daschbach, L. De Ventier, T. Done, M. Eakin, U. Engelhardt, M. Fenton, W. Fisher, S. Gittings, A. Grottoli, L. Hale, L. Hansen, J. Hendee, J. Innes, T. McClanahan, L. McCook, K. Michalek-Wagner, J. Nevill, M. Nystrom, A. Paterson, J. Schittone, L. Pet Soede, G. Ricci, K. Sherwood, W. Skirving, A. Strong, K. Teleki, and D. Wachenfeld. 2006. *A Reef Manager's Guide to Coral Bleaching*. Great Barrier Reef Marine Park Authority.

Yale Framework for Integrating Climate Adaptation and Landscape Conservation Planning. <www.Yale.DataBasin.org>.

Climate science resources by region

International

Intergovernmental Panel on Climate Change. 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.). Cambridge, UK: Cambridge University Press, Cambridge. <www.climatechange2013.org/>

Intergovernmental Panel on Climate Change. 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.). Cambridge, UK: Cambridge University Press, Cambridge. <www.ipcc.ch/report/ar5/wg2>

Intergovernmental Panel on Climate Change (IPCC). 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.). Cambridge, UK: Cambridge University Press, Cambridge. <www.ipcc.ch/report/ar5/wg2>

Data Basin. www.DataBasin.org

Crescent gunnel (*Pholis laeta*)
Pacific Rim National Park Reserve

Jennifer Yakimishyn

Canada

Environment and Climate Change Canada. Canadian Climate Data and Scenarios. <www.ccds-dscc.ec.gc.ca>

Lemmen, D.S., Warren, F.J, James, T.S. and Mercer Clarke, C.S.L. editors (2016): Canada's Marine Coasts in a Changing Climate. Government of Canada, Ottawa, ON. 274 p. (available at adaptation.nrcan.gc.ca)

Tillmann, P. and D. Siemann. 2011. *Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region: A Compilation of Scientific Literature*. Washington, DC: National Wildlife Federation.

United States

Melillo, J.M., T.C. Richmond and G.W Yohe (eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

Committee on Sea Level Rise in California, Oregon, and Washington, Board on Earth Sciences and Resources, Ocean Studies Board, Division on Earth and Life Studies, National Research Council. 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. National Academies Press. DOI: 10.17226/13389.

Mexico

Cavazos, T. and S. Arriaga-Ramírez. 2012. Downscaled Climate Change Scenarios for *Baja California and the North American Monsoon during the Twenty-First Century*. Journal of Climate.

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Brundell, J., D. Cobon and G. Stone. 2011. *Climate Change Risk Management Matrix: a process for assessing impacts, adaptation, risk and vulnerability*. Toowoomba, OLD: Queensland Climate Change Centre of Excellence.

Commission for Environmental Cooperation. 2012. *Guide for Planners and Managers to Design Resilient Marine Protected Area Networks in a Changing Climate*. Montreal, QC, Canada: Commission for Environmental Cooperation.

Commission for Environmental Cooperation. 2011. *A Guide to Ecological Scorecards for Marine Protected Areas in North America*. Montreal, QC, Canada: Commission for Environmental Cooperation.

CONANP, CEGAM, Alianza, WWF, Fundación Carlos Slim. 2015. Herramienta para el Diagnóstico Rápido de Vulnerabilidad al Cambio Climático en Áreas Naturales Protegidas. Secretaría de Medio Ambiente y Recursos Naturales. México. (Translated).

Gittings, S.R., M. Tartt and K. Broughton. 2013. *National Marine Sanctuary System Condition Report 2013*. Silver Spring, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries.

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Hutto, S.V. (ed.). 2016. *Climate-Smart Adaptation for North-central California Coastal Habitats. Report of the Climate-Smart Adaptation Working Group of the Greater Farallones National Marine Sanctuary Advisory Council*. San Francisco: Greater Farallones National Marine Sanctuary, National Oceanic and Atmospheric Administration.

Office of National Marine Sanctuaries. 2010. *Gulf of the Farallones National Marine Sanctuary Condition Report 2010*. Silver Spring, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries.

Reynier, W. and L.J. Hansen. 2015. *Coastal and Marine Adaptation Strategies and Actions*. Bainbridge Island, WA: EcoAdapt.

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