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**

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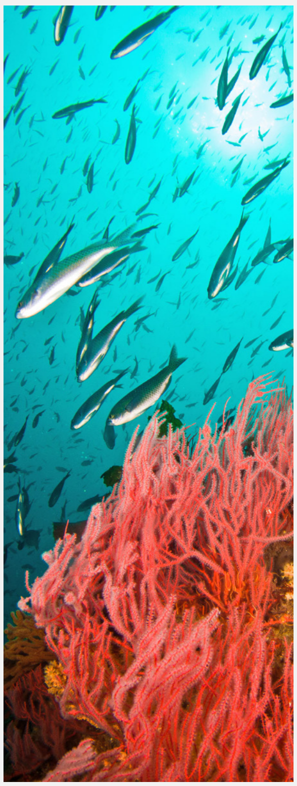
North American

Marine Protected Area

Rapid Vulnerability Assessment Tool




Example of Completed Worksheets

Commission for Environmental Cooperation

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

Dr. Dwayne Meadows, NOAA/NMFS/OPR.

North American

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Rapid Vulnerability Assessment Tool

Example of Completed Worksheets

Rapid Vulnerability Assessment Summary

Step 1
Define the scope of the vulnerability assessment

Select the parameters that define your site and management priorities.

Step 2
Construct your assessment matrices

On the following pages you will transfer your choices from **Step 1** to create your Assessment Matrices.
Use the following guidance to assist, but see full details in the *Rapid Vulnerability Assessment Tool User Guide*.

Step 3
Undertake your assessment

Undertake your assessment by completing Tables 1-3 with available science and local knowledge.
Wherever applicable, indicate the references that provided the information used.

Table 1: Vulnerability Assessment

Column A: List the relevant climate change stress selected in **Step 1**.

Column B: Describe what you know about the direction and magnitude of the observed or projected change.

Column C: Describe the anticipated effect of each climate change stress listed on this habitat type.

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. In doing this you are considering certainty based on your knowledge of the evidence and consensus of the interpretation of this evidence.

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)

Column E: Insert Consequences from the final row of **Table 2**.

Column F: Using **Figure A,** determine the Risk relating to this climate stress for this habitat type.

Column G: Transfer Adaptive Capacity assessment from the final row of **Table 3**.

Column H: Find the **Vulnerability** based on the Risk (**Column F**) and Adaptive Capacity (**Column G**) using **Figure B**.

Repeat this process for each habitat type.

Table 2: Consequences

Column A: List the relevant non-climate stressors from **Step 1**.

Column B: Describe how these non-climate stressors have currently or historically affected this habitat.

Column C: Indicate if climate change is expected to make these effects better (less problematic) with a (+) or worse (more problematic) with a (-).

Column D: In each box at the top of **Column D**, list the climate change stresses considered in **Column A** of **Table 1**. What is the combined impact of each non-climate stressor with each of these climate stresses?

Bottom Row: **Consequence**. Considering the direct effects of the climate stress and the combined effects of all of the non-climate stressors on each climate stress, what will be the consequence of the effect on this habitat type given what you know? *If positive consequences are identified, they will be addressed in the narrative vulnerability assessment.*

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

Table 3: Adaptive Capacity Assessment

Column A: Add additional ecological or social factors that may affect your ability to support adaptation in this habitat type.

Column B: Indicate the status of each social factor and condition of each ecological factor on a scale from 1 to 5. Provide rationale for the ranking.

5=Superior, 4=Good, 3=Fair, 2=Poor, 1=Critical

Bottom Rows: **Average**: Find the average for all factors in each category.

Combined Average: Find the average of ecological and social potential combined.

Adaptive Capacity: Convert the combined average to an adaptive capacity score of **High**, **Moderate** or **Low**, using the conversion tool at the bottom of the page.

Step 4
Adaptation strategy development

For each stress with a high or moderate vulnerability score, develop a list of adaptation strategies that could reduce that vulnerability. Where possible, consider strategies that address multiple vulnerabilities.

Step 5
Create your own narrative vulnerability assessment report

Use the results of all completed habitat assessments to create a narrative vulnerability assessment for your site.

Sheri Phillips, NOAA/NESDIS/NODC

Rocks, surf, fog, seaweed, and fog-enshrouded headland at Ecola State Park, Oregon.

Step 1
Define the scope of the vulnerability assessment

Box 1.
What habitat types are you considering for this assessment? (Select 3 that are your priorities)

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

Box 2.
What timescale are you interested in assessing? (Select 1)

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

Box 3.
What climate change variables are likely to affect these habitats? (Select 3 that are your priorities)

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

Box 4.
What non-climate stressors currently affect these habitats? (Select 3 that are your priorities)

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

Step 3
Undertake your assessment

Table 1. Vulnerability Assessment

Location: Greater Farallones NMS		**Habitat Type:** Rocky Intertidal				**Timescale:** Medium term (next 50 years)	
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) and Key Drivers**
Sea-Level Rise (SLR)	Sea-level rise projections for northcentral California: 12-61 cm of sea-level rise is expected by 2050 and 42-167 cm is expected by 2100.	Flooding and inundation of habitat – long-term impact is that zonation will shift upland and high intertidal may have nowhere to go.	Likely	Catastrophic	Extreme	High	Moderate Key drivers: Likelihood and Consequence
Ocean Acidification (OA)	Saturation state of aragonite is projected to drop rapidly in the CCS within the next 30 years, with summertime under saturation in the top 60 meters; by 2050, more than half of the waters in the CCS will be under saturated year-round.	Impede the ability of calcifying organisms to build calcium carbonate shells, and potentially result in the dissolution of existing shells (evidence for CA mussel and coralline algae) – this would alter community dynamics of rocky intertidal habitat.	Almost certain	Major	Extreme	Moderate	High Key drivers: All
Storm Severity/ Frequency	Winter storms have been increasing in frequency and intensity since 1948; peak storm wave heights have been increasing along the Pacific Coast; increased intensity expected.	Intertidal organisms will experience more frequent and intense physical forces due to wave action - selective removal of larger intertidal organisms, may influence size structure & species interactions & increased coastal erosion that may result in buried intertidal habitat.	Possible	Moderate	Medium	High	Low Key drivers: Potentially all

Table 2. Consequences

Location: Greater Farallones NMS	**Habitat Type:** Rocky Intertidal		**Timescale:** Medium term (next 50 years)		
		Ⓒ Will climate change make this better or worse? (+)(-)	**Ⓓ What is the combined impact of this non-climate stressor and... [Insert your three climate stresses here]**		
Ⓐ Non-climate stressor	**Ⓑ How does this stressor affect this habitat type?**		SLR	OA	Storms
Pollution	Pollutants, including agricultural and livestock waste, wastewater, sewage outfalls, historic mining, and industrial wastes, can be carried into the study region via the freshwater outflow from SF Bay, inhibiting habitat resilience and stimulating phytoplankton growth.	(-) due to changing precipitation (more intense and less frequent)	SLR may cause inundation of infrastructure that can result in increased pollution and exposure to toxins.	Organisms that are less resilient due to OA will be less tolerant to pollution.	Similar to SLR, storms may result in greater inundation and damage to coastal infrastructure, potentially increasing exposure to pollution.
Invasive Species	Invasive species threaten the abundance and/or diversity of native species, disrupt ecosystem balance and threaten local marine-based economies.	(-) due to increasing sea surface temp	Habitat zonation will already be under stress due to increasing inundation; invasives will exacerbate disruptions to the intertidal community	Non-calcifying invasives will better be able to out-compete calcifying natives.	Invasive species love disruption – the more disruption (via increased storm severity), the more successful some invaders will be.
Recreation	The high visitation levels that occur in the rocky intertidal can cause crushing of organisms and changes in the diversity and abundance of organisms.	(-) due to increased visitation to escape central valley heat	SLR will squeeze intertidal habitat into a narrower band – impact from trampling will be felt more strongly.	Calcifying organisms may not be able to recover from exacerbating impact of OA with trampling.	Trampling and storms cause exacerbated disruption to intertidal organisms.
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)			Catastrophic	Major	Moderate

Table 3: Adaptive Capacity Assessment of Habitat

	C 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.]	
A Ecological Potential	**Habitat:** Rocky Intertidal	**Rationale:**
Extent, Distribution & Connectivity	3	Fairly populated ecosystem with multiple uses and development
Past Evidence of Recovery	3	There have been unrecovered from changes in the system
Value/Importance	4	Locally valued habitat type
Physical Diversity	4	Good deal of heterogeneity in the presentation of this habitat type
Biodiversity	5	All iconic species of this habitat type present
Keystone & Indicators Species	4	Sea star wasting disease has impacted system
Other:		
Ecological Potential Average	3.8	

B Social Potential		
Organization Capacity		
Staff Capacity (training, time)	4	
Responsiveness	3	Long-term priorities may be slow to change
Stakeholder Relationships	4	Sanctuary advisory council and other collaborations
Stability/Longevity	5	
Other:		
Management Potential		
Existing Mandate	5	Management requires response to environmental stressors
Monitoring & Evaluation Capacity	4	Many entities conducting long-term and topic monitoring in region
Ability to Learn and Change	4	
Proactive Management	3	
Partner Relationships	4	
Science/Technical Support	3	General climate science available, not specifics for all species
Other:		
Social Potential Average	3.9	

Combined Potential Average	3.9	
Adaptive Capacity	High	

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

Table 4. Strategy Development

Ⓐ Vulnerability	Ⓑ Strategies	Ⓒ Cost (H/M/L)	Ⓓ Efficacy (H/M/L)
SLR: Likelihood (reduce exposure to SLR)	Create artificial rocky intertidal habitat that is elevated to ensure the habitat can persist (species can migrate) as SLR causes increased inundation.	H	L
SLR: Consequence (reduce sensitivity to SLR)	Remove and/or redesign roads and other coastal infrastructure to allow for rocky intertidal habitat to migrate inland in response to SLR.	H	M
OA: Likelihood (reduce exposure to OA)	Pursue and encourage research in OA-mitigation methods including the restoration and expansion of photosynthesizers (kelp, surfgrass) to locally mitigate the impacts of OA and sequester carbon.	M	M
OA: Consequence (reduce sensitivity to OA)	For OA-vulnerable species (coralline algae, CA mussel), consider managing for the presence of other species that can fill that ecological niche so the habitat retains its function and remains resilient, even if some species are lost.	L	M
OA: Adaptive Capacity	Implement extensive monitoring of OA across the rocky intertidal habitat throughout the Sanctuary and support research of OA-mitigation methods that may be implemented rapidly following severe OA crisis.	H	M

Table 5. Strategy Implementation

Ⓐ Strategy	Ⓑ Leader and potential partners	Ⓒ Monitoring and evaluation criteria	Ⓓ Funding/Costs	Ⓔ Existing or needed management mechanisms	Ⓕ Timeline
Remove and/or redesign roads and other coastal infrastructure to allow for rocky intertidal habitat to migrate inland in response to SLR.	Caltrans as lead, local county/city partners, Sanctuary, California Coastal Commission, National Park Service	Once road is removed, need to monitor for movement of intertidal zonation and habitat functionality.	Needs project coordinator and adequate resources for assessments	Do not anticipate the need for policy change in order to implement. Post-disaster planning might need to interface with local hazard mitigation plans. Likely requires permit and environmental impact review.	Depending on the urgency (highway that is already being inundated or intertidal area already inundated) would range from near (next 20 years) to mid (next 50 years) term.
Pursue and encourage research in OA-mitigation methods including the restoration and expansion of photosynthesizers (kelp, surfgrass) to locally mitigate the impacts of OA and sequester carbon.	Sanctuary (support from CDFW, State Parks, NPS, BLM, local counties)	Theory needs to be vetted (some work underway in WA) before implementing. Once implemented, monitor for changes in pH at various distances from source vegetation and track any potential impacts on OA-vulnerable species.	Sea Grant funding to research institutions	CCC approval and permits for test plots.	Near-term

Step 5
Create your own narrative vulnerability assessment report

Greater Farallones National Marine Sanctuary assessed the vulnerability of 44 focal resources in the North-central California coast and ocean region, including eight habitats, populations of 31 species, and five ecosystem services. Multiple climate stressors were considered, including air and sea surface temperature, precipitation, salinity, oxygen, pH, sea-level rise, wave action, currents/mixing, and coastal erosion. Most resources considered in this assessment were identified by workshop participants as moderately vulnerable to climate change, with a range from low-moderate vulnerability to moderate-high vulnerability. Coastal habitats in the study region, including beaches and dunes, estuaries, and the rocky intertidal, along with associated species and ecosystem services, were identified through this assessment as being most vulnerable, and will likely be prioritized for future management action.

The most vulnerable habitats, beaches/dunes, estuaries, and rocky intertidal, exist at the land-sea interface. These habitats are expected to experience greater exposure and sensitivity to climate changes and non-climate stressors. Climate-driven stressors, in particular sea-level rise, wave action, and coastal erosion, are expected to exacerbate flooding and inundation of these habitats and lead to disturbance to the structural and functional integrity of the habitats due to increased storms, wind, and wave events. Existing non-climate stressors for these habitats include coastal armoring and invasive species. Coastal armoring inhibits the ability for a habitat to migrate inland or upland in response to rising sea level, and accelerated, localized loss of habitat may be expected in areas where the upland border of the habitat abuts roads, levees or other armored structures. Invasive species threaten the abundance and/or diversity of native species, disrupt ecosystem balance, threaten local marine-based economies and can even alter the habitat itself (for example, by altering dune morphology).

Vulnerability for beach/dune habitats was greatest for sea-level rise and coastal erosion, due to flooding and inundation that will lead to habitat loss. An adaptation strategy that might reduce this vulnerability is beach nourishment. In order to implement this strategy, we will need cooperation and potentially permits from the Army Corps of Engineers, landowners such as the National Park Service, State Parks, cities and counties, the Coastal Commission, Sanctuary and the Coastal Sediment Management Workgroup, as well as funds and a clean sediment source.

Vulnerability for outer coast estuaries was greatest due to sea-level rise related flooding and saltwater intrusion. Adaptation strategies that might reduce this vulnerability are removal or redesign of roads and other barriers to estuary migration inland, which require local governments working with state agencies for appropriate permitting, funding, and environmental review.

Vulnerability for rocky intertidal habitat was greatest for air temperature due to heat stress experienced by intertidal organisms that may lead to mass mortality events. An adaptation strategy that might reduce this vulnerability is the restoration of surf grass and algal species to act as aqueous canopies providing shade to reduce temperatures and evaporation in tide pools. This would require scientific inquiry and pilot projects to determine feasibility and efficacy, and cooperation among numerous state and federal agencies for implementation, with funding and permitting.

Commission for Environmental Cooperation
393, rue St-Jacques Ouest, bureau 200
Montreal (Quebec)
H2Y 1N9 Canada
t 514.350.4300 f 514.350.4314
info@cec.org / www.cec.org