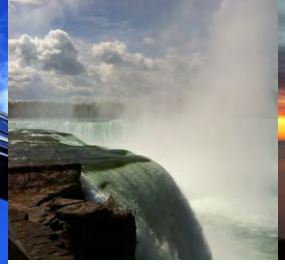
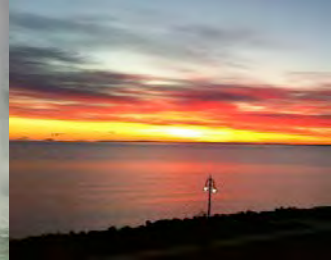
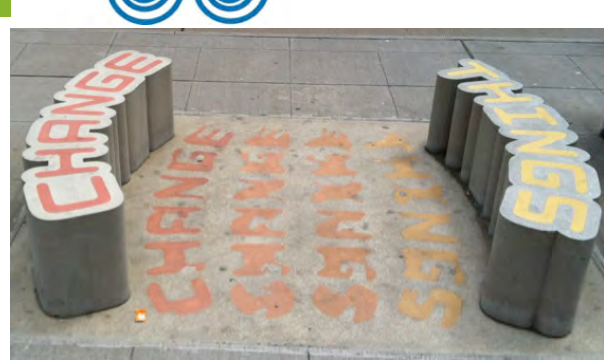


The Climate Adaptation Toolkit for Fisheries Management

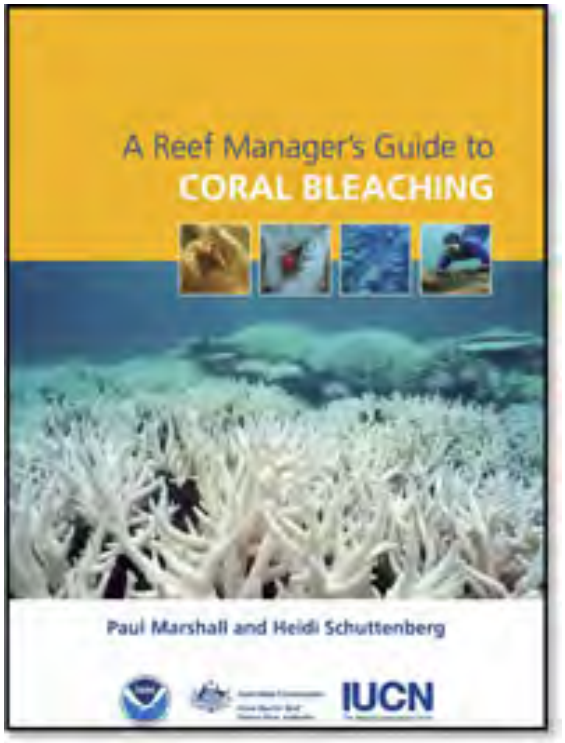


Lara J. Hansen, EcoAdapt
Alex Score, EcoAdapt
Roger Griffis, NOAA
and
Carolyn Lundquist, NIWA

Funded by National Oceanic Atmospheric Administration Climate Program Office
Travel support from Wood Hole Oceanographic Institute

Adaptation in Management- a model

Expert-peer Guidance



Access to necessary Data

Coral Reef Watch

Immersive training

Reef Resilience Network

Adaptation in Fisheries Management

Understand Implications of climate change for the fish, the habitat and the fishery

Improve fisheries management and fishing practice to develop *durable* outcomes

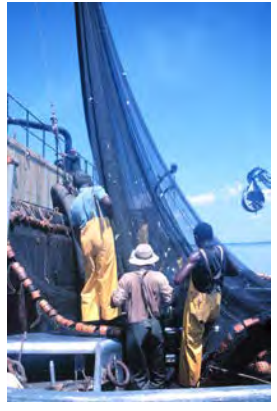
Vulnerability Assessment

Adaptation Strategy Development

Implementation

Project Objectives

1. **Assess impacts** of climatic and non-climatic stressors on fisheries.
2. **Survey the needs** of fishery managers seeking to address climate change.
3. **Facilitate development and continued improvement of adaptation option**s for fisheries through surveys of climate-informed fisheries management to date.
4. **Synthesis report and case study examples** of adaptation in practice in fisheries management.
5. **Centralized climate fisheries dashboard** (portal and network) to promote and sustain these efforts.



Impacts to Fisheries: Increased Air and Sea Temperature

Observed changes	Projected future changes	Potential impacts on fisheries
• U.S. mean air temperature increased between 0.72-1.05°C (1.3-1.9°F) since 1895 • Last decade was the warmest on record • Most drastic increases in temperature since the 1970s • Average sea surface temperature increase of 0.5°C (0.9°F) over past century • Strongest warming trends in surface waters • Fluctuations in annual mean temperature due to natural inter-annual and decadal variability could cause temporary greater warming (e.g., ENSO, PDO)	• Continued warming, with faster projected rate of change and average air temperatures 1.66-2.77°C (3-5°F) warmer by 2100 • Ocean warming likely to continue increasing beyond 2100 • Warming oceans will lead to other climate shifts (e.g., rising sea level, increased water stratification, shifts in ocean circulation) and impacts (e.g., increasing toxicity of pollutants, hypoxia, invasive species)	• Cod fisheries collapse in the Gulf of Maine • Poleward shifts of many species due to warming ocean temperatures • Potential for increased catch in Alaska due to northward shift of species • Some species (e.g., Atlantic cod [*Gadus morhua*]) shifting deeper to find cooler waters • Declines likely to occur at the southern end of species range and in tropical areas • Potential increases in abundance and catch (e.g., Pacific sardine, Atlantic croaker) • Phenological shifts (e.g., changes in development and timing of spawning and growth, altered timing of migrations) • Decreased body size of certain fish species due to thermal stress and altered physiology

Impacts to Fisheries: Precipitation

Observed changes	Projected future changes	Potential impacts on fisheries
• Changes in precipitation patterns vary across the United States, with an average increase in precipitation since 1900 • Observed increased frequency of extreme precipitation events in last 3 to 5 decades	• Northern U.S. likely to experience more frequent and intense precipitation • Southwest likely to see drier conditions • Shifts between intense rainfall and intense drought in Gulf of Mexico • Pacific Northwest likely to experience higher average and more concentrated precipitation	• Shifts in species composition of anadromous and estuarine species (e.g., salmon) attributable to salinity changes in coastal areas • Altered reproductive timing and success of anadromous species due to timing of seasonal droughts and flooding • Inundation of coastal fish habitat (e.g., mangroves, tidal marshes, shallow corals)

Impacts to Fisheries: Increased Storm Frequency and Intensity

Observed changes	Projected future changes	Potential impacts on fisheries
• Number of Category 4 and 5 storms in the Atlantic basin has increased substantially since the 1980s • In the coastal Northeast and Norwest, increased intensity and frequency of winter storms	• Continued rise in intensity, frequency, and duration of storms • Southeast United States and Gulf of Mexico likely to be greatly affected by increased storms	• Expanded habitat destruction (e.g., coastal flooding, coral reef damage) • Decreased fishing effort due to loss of fishing days and bad weather • Higher fishery insurance expenses • Greater economic risks associated with the fishing industry • Increased economic vulnerability of fisheries-dependent communities (subsistence, traditional fisheries) due to decreased fishing days and increased insurance rates • Direct disturbance to fishing operations and infrastructure

Impacts to Fisheries: Ocean Circulation and ENSO

Observed changes	Projected future changes	Potential Impacts on fisheries
• 1983 and 1998 ENSO events were stronger than other ENSO events over the past century • 2015/16 event has tied with the 1998 El Niño as the strongest on record	• Weakening of thermohaline circulation • Increased frequency/ intensity of warm ENSO events • Temporal shifts in and intensification of upwelling	• Altered species distribution and migration patterns of fish populations due to decreases in primary and secondary productivity • Declines in net primary productivity and limited prey availability • Loss of fishery productivity • Shifts in species composition and productivity of various species • Shifts in fish spawning and larval composition, leading to potential variations in stock productivity

Impacts to Fisheries: Sea Level Rise

Observed changes	Projected future changes	Potential impacts on fisheries
• Rising sea level due to melting glaciers, ice sheets, and thermal expansion of oceans • In United States, observed average sea level rise of ~8 inches since the late 1800s • Sea level rise rates faster in some regions of the country than others (e.g., Chesapeake Bay, Gulf Coast) due to flat topography and land subsidence	• Projected continued increase of 1 to 4 ft. by 2100 and at a faster rate than previously • 21st century rate of sea level rise likely to exceed rates observed to date due to continued warming and melting • Increased rates of sea level rise in Gulf Coast due to flat topography, shoreline subsidence, and shoreline development	• Degradation of key fish and shellfish habitat (e.g., tidal marshes, mangroves, coral reefs, submerged vegetation) • Flooding and habitat degradation will decrease nursery habitat for fisheries • Increased economic vulnerability of fisheries-dependent communities (subsistence, traditional fisheries) due to damage to or disturbance of infrastructure and operations

Impacts to Fisheries: Ocean Acidification

Observed changes	Projected future changes	Potential impacts on fisheries
• Oceans have absorbed ~ 1/3 of total CO_2 emissions in the last 200 years • Observed 30% increase in ocean acidity (0.1 unit decrease in pH)	• Continued pH decline as ocean absorbs more atmospheric CO_2 • Alaska and the West Coast strongly affected due to cold, CO_2 rich waters • In coral reef regions, acidification will likely exacerbate coral reef decline	• Changes in shellfish development, age of sexual maturity, timing of spawning, growth, and survival • Decrease in shell or skeleton growth rates and morphology • Loss of habitat for coral reef fish and shellfish, and potential decrease in species • Shifts in species composition and distribution • Decreases in zooplankton abundance and limited prey availability

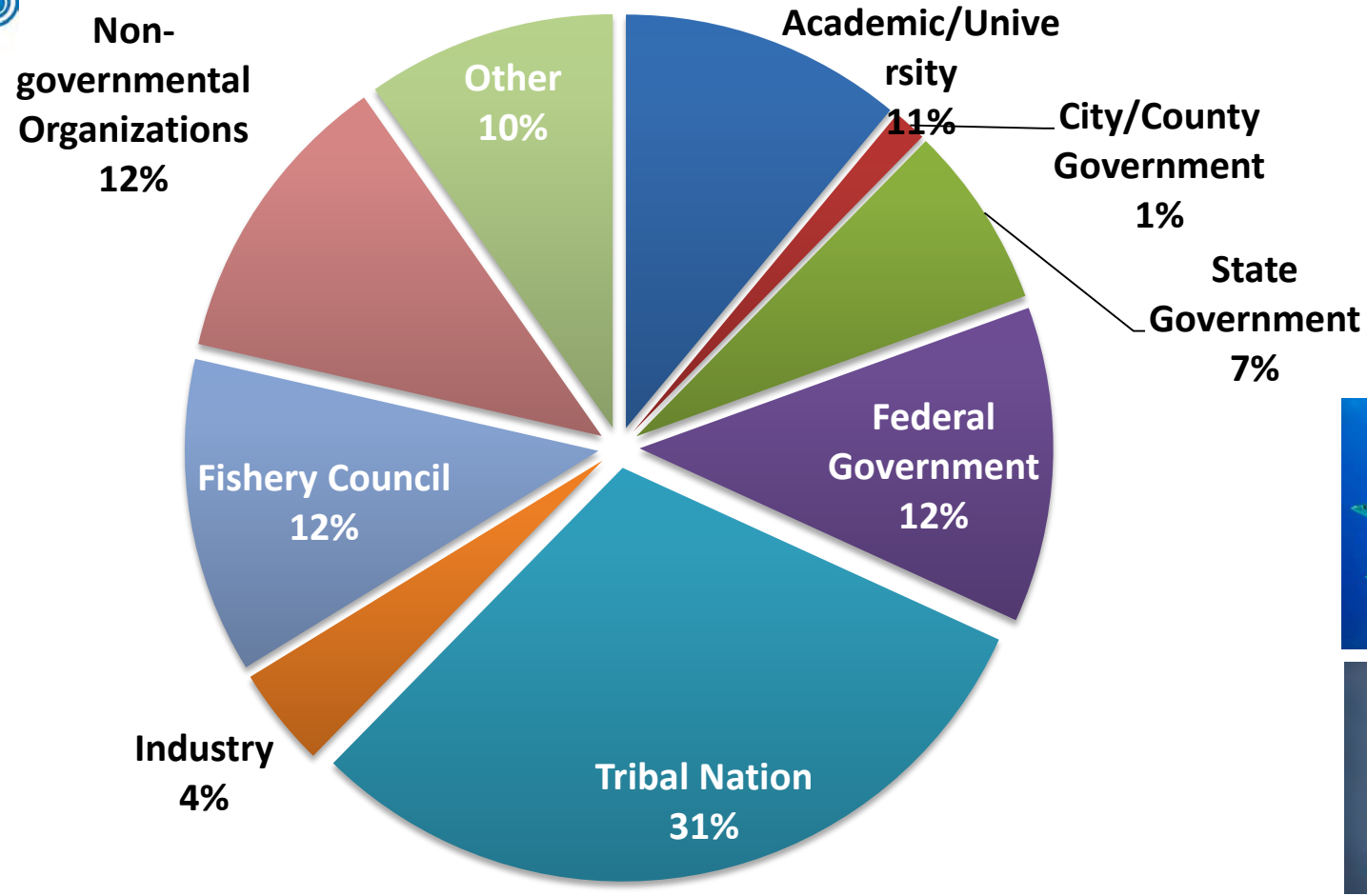
Impacts to Fisheries: Non-Climatic Factors

Non-climate stressor	Observed trends and projected future changes	Interactions with climatic stressors
Overfishing	• Some U.S. fish stocks previously depleted and although many are rebuilt, 8% are on the overfishing list and 16% still considered overfished • Previously depleted stocks could recover if managed sustainably and able to adapt to climate stressors	• Depleted fish stocks are highly vulnerable to climate stressors • Stocks with range shifts and contractions will be vulnerable to potential concentrated fishing pressure • Larval and juvenile habitat loss will limit stocks' ability to replenish • Potential for new fishing pressure on stocks in new areas
Bycatch	• Bycatch a current source of mortality for many species • Fisheries observer programs and ongoing research on technological solutions for bycatch may help minimize bycatch levels	• Stocks caught as bycatch (e.g., yellowtail flounder) more vulnerable to climatic stressors • Potential for new species bycatch or declines in levels of some traditional bycatch species due to increased temperature and range shifts • Range shifts or contractions could lead to more concentrated fishing efforts and increased bycatch
Pollution	• Nutrient pollution triggering greater frequency of toxic harmful algal blooms • Increased mercury in fish • Bioaccumulation of PAHs causing immunosuppression in fish • Impaired cortisol stress response in fish from exposure to mercury, PAHs, and PCBs • Male fish species producing female egg protein after exposure to endocrine disruptors	• Potential for greater nutrient and pollutant runoff from increased storm intensity and frequency • Higher levels of nutrients in the water leading to increases in hypoxic and acidic areas, causing fish kills • Temperature-induced increases in production of methyl mercury could result in increased mercury levels in fish

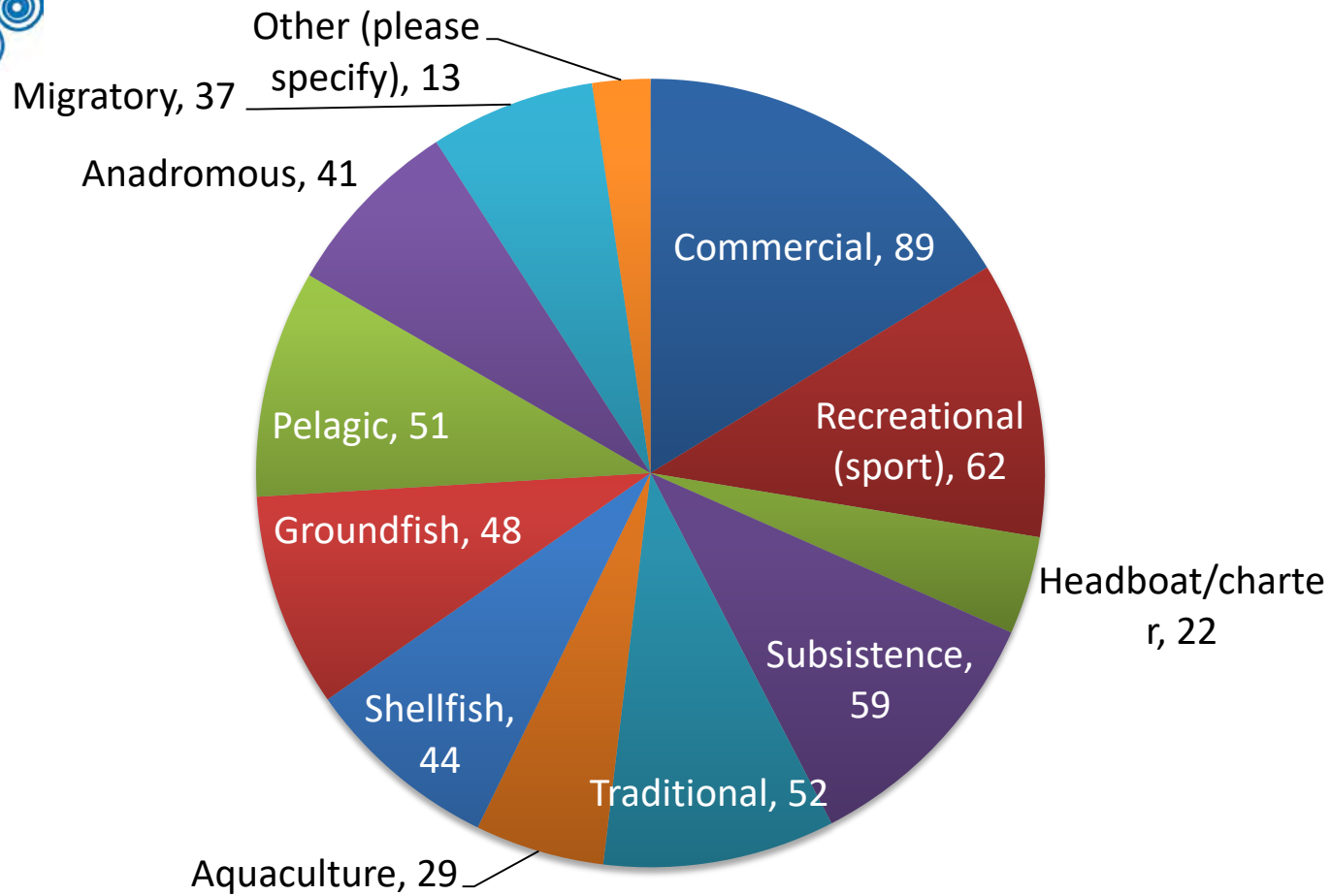
Impacts to Fisheries: Non-Climatic Factors (cont.)

Non-climate stressor	Observed trends and projected future changes	Interactions with climatic stressors
Habitat degradation/ modification	• Human development activities (e.g., shoreline dredging, coastal development) could modify or degrade important habitat for fish species • Removal of riparian vegetation could limit shade availability for fish species vulnerable to warm temperatures (e.g., bull trout)	• Degradation of mangrove habitat due to dredging and development could lead to reductions in fish nursery and juvenile habitat • Human-induced reef degradation (e.g., destructive fishing practices, boat groundings, trampling of corals) will compound damage to reefs from bleaching, acidification, storms, and runoff
Invasive and non-native species	• Greater success of invasive species (e.g., lionfish in the Caribbean) and competition with native fish • Introduction of new non-native species through a variety of methods (e.g., ballast water, accidental release)	• Warming oceans may facilitate survival of invasive competitors and predators of native fish species (e.g., the invasive European green crab, which has negatively impacted California and Maine clam populations), leading to changes in community structure
Conflicting uses of marine and coastal ecosystems	• Uses of coastal zone (e.g., oil and gas platforms, aquaculture facilities, coastal development) can lead to modification of fish habitat or limiting access to viable fishing grounds	• Coastal engineering (e.g., offshore platforms) could reduce/remove nursery habitat, leading to lower recruitment and compounding effects of climate stressors

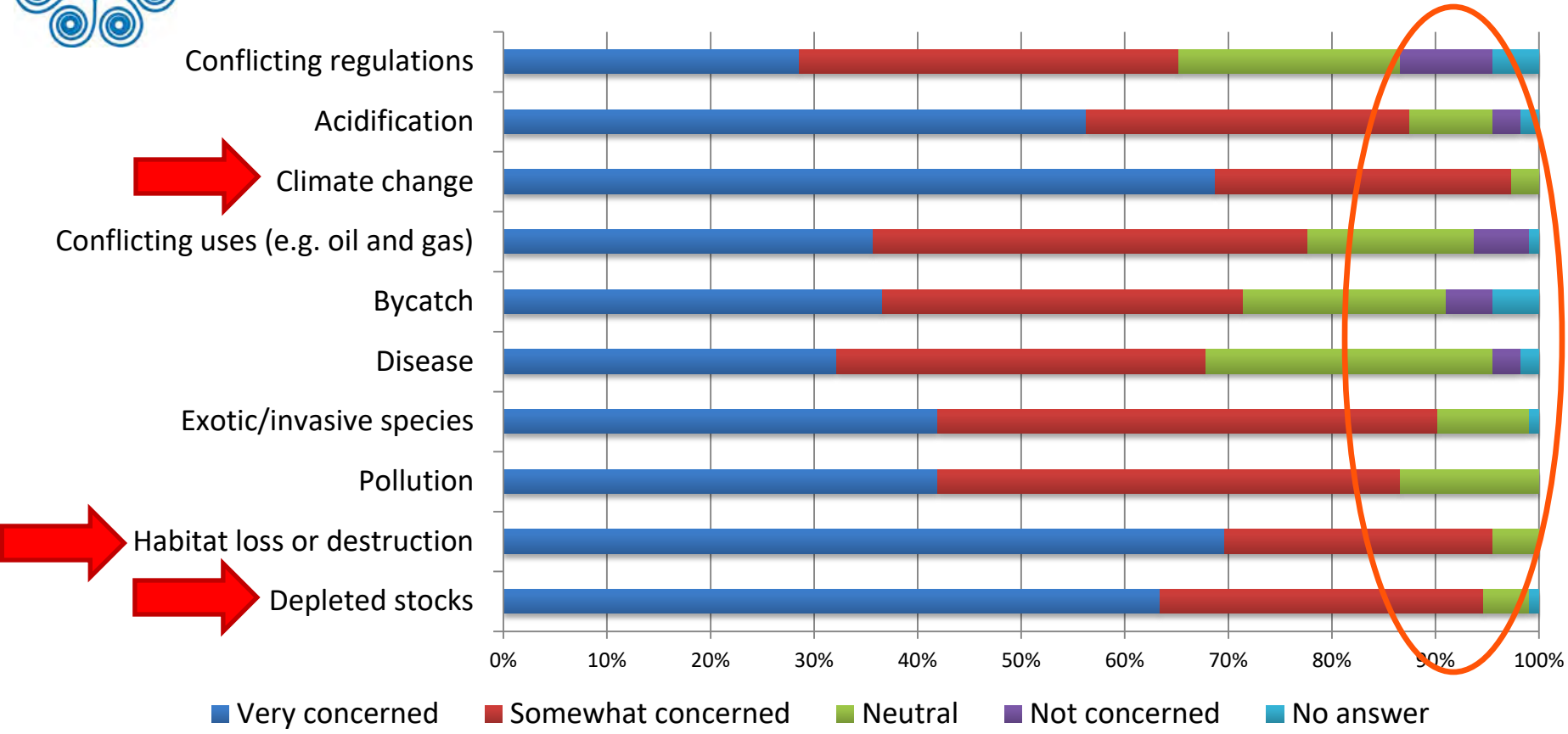
Need Assessment: By Professional Affiliation



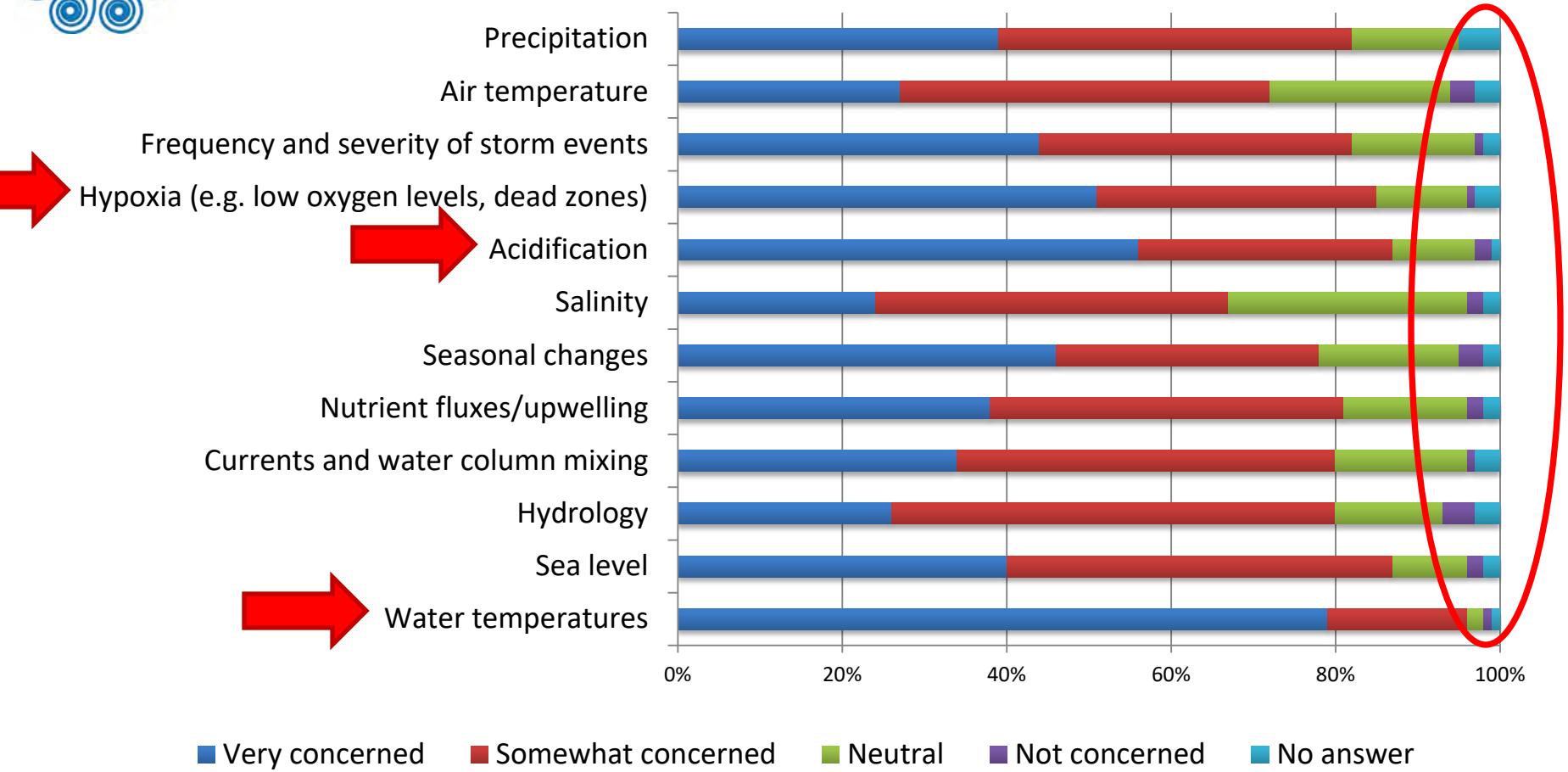
Need Assessment: By Fishery



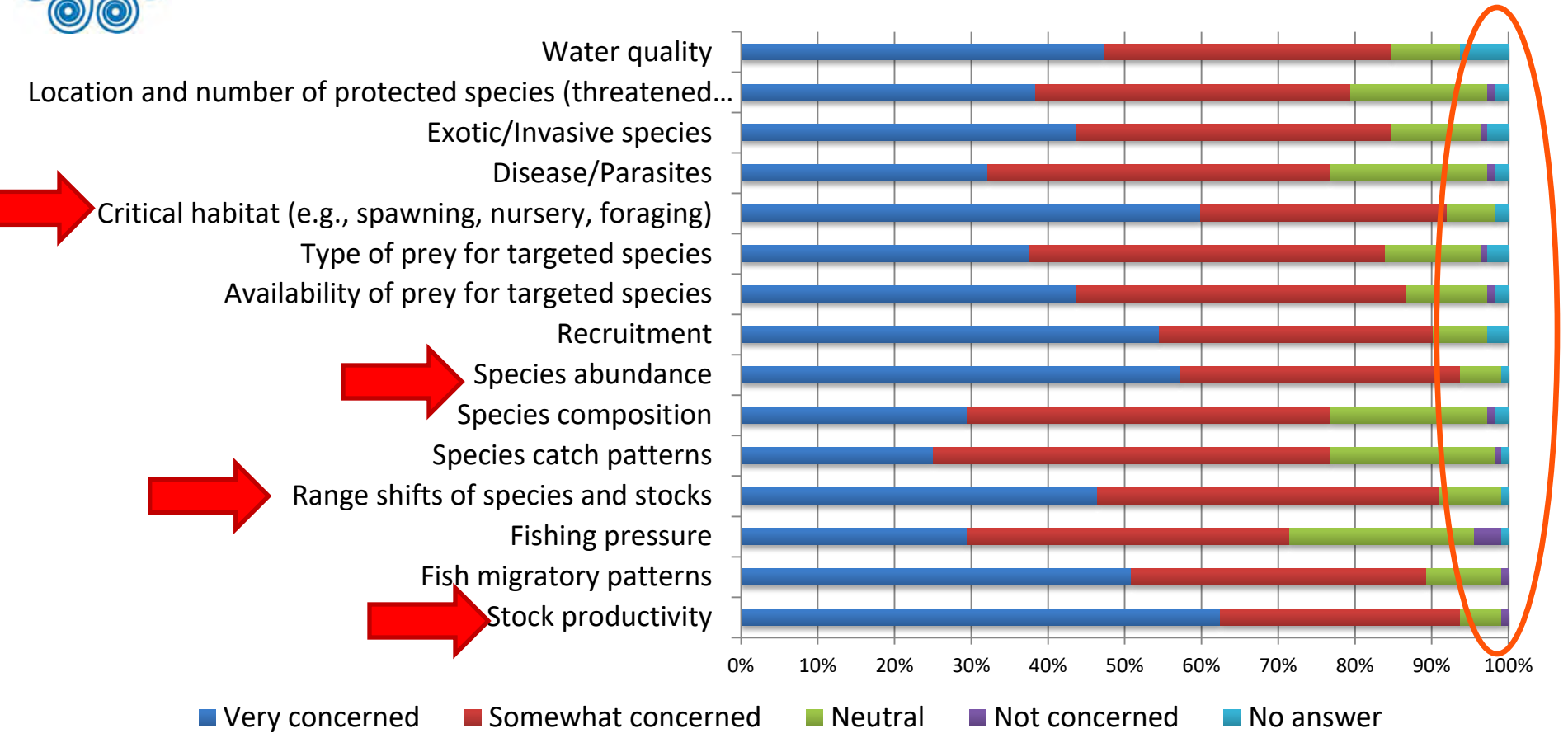
Need Assessment: Fisheries Concern



Need Assessment: Climate Impacts Concern



Need Assessment: Concerns of other direct and indirect impacts



Need Assessment: Tools for Decision Support

- Fishery and monitoring data
- Stock assessment
- Fishery model
- Sharing of traditional knowledge
- Case studies
- Best practices
- Map and spatial data
- Regional vulnerability assessments
- Species and habitat vulnerability

Need Assessment: Adaptation Strategies

climate
impacts
innovative
Research
Flexible
fisheries
regional
adaptation
Assessments
science
MPAs
models
restoration
implement
Synergistic
habitat
respond
Feasibility
ecosystem
Long-term
permits
landings
monitoring
Enhance
approach
Protect
sustainable
Ecosystem-based
buffer
management
mitigation
Precautionary
precautionary
plans
cryopreservation
response
Monitoring
flexible
industry-based
relationships
limits
trigger
communication
networking
Adaptive
realignment
changing
ecosystem-based
Integrated
change
thresholds
Mariculture
Ecosystem
fishermen
indicators
Rebuild
develop
Testing
Risk-averse
cooperation
collaboration
quotas
conditions
coordinated
efficient
assessment
protection
Scenarios
effects
Access
harvest

Case Studies: Adaptation Options

1. Capacity Building
2. Policy
3. Natural Resource Management and Conservation
4. Infrastructure, Planning and Development

Case Studies: Capacity Building

1. Research and assessments
2. Training and planning exercises
3. Increase/improve public awareness, education, and outreach efforts
4. Create/enhance resources and tools
5. Monitor climate change impacts and adaptation efficacy

Case Studies: Policy

1. Develop/implement adaptation plans
2. Create new or enhance existing policies or regulations
3. Develop/implement adaptive management strategies




Case Studies: Natural Resources Management & Conservation

1. **Incorporate climate-informed guidelines into restoration**
2. **Enhance connectivity and areas under protection**
3. **Reduce local climate or related change**
4. **Reduce non-climate stressors likely to interact with climate change**



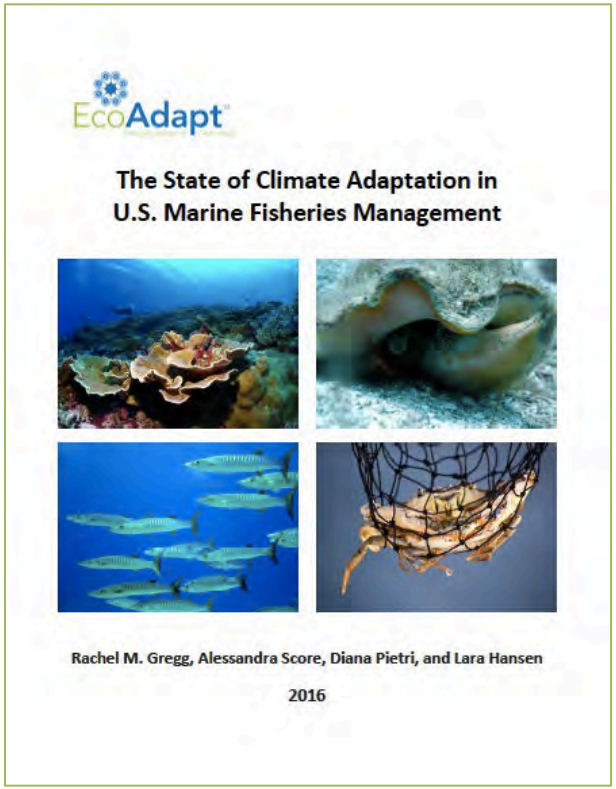

Case Studies: Infrastructure, Planning, and Development

1. **Make infrastructure resistant or resilient to climate change**
2. **Create or modify shoreline management measures**

Case Studies: Management Options (a sampling)

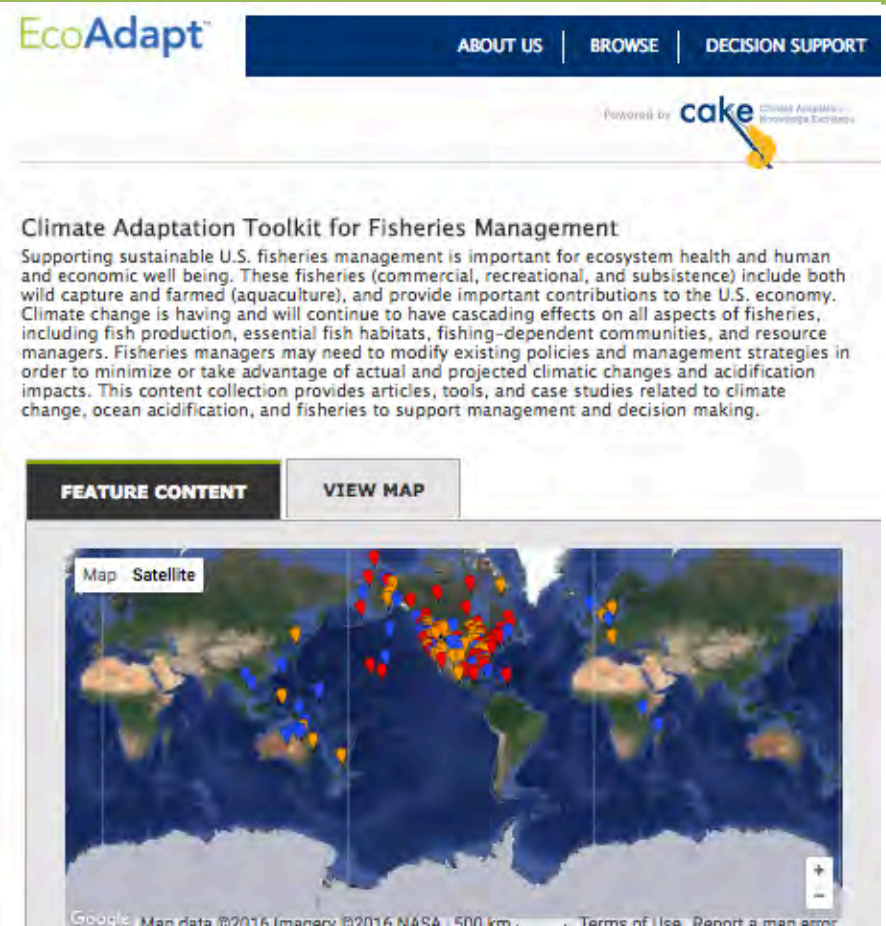
Management Challenge	Management Relevance			Potential Management Options
	Abundance and Productivity	Distribution and Recruitment	Habitat Degradation and Loss	
Increased vulnerability of fish stocks to current levels of fishing pressure due to shifting species ranges	X	X		• Conduct stock assessments to document new species ranges and abundance in response to changing conditions • Adjust quotas to help sustain stocks (e.g., reduce fishing pressure on vulnerable stocks) • Temporarily close fisheries if necessary
Redistribution of stocks due to warming temperatures and associated species range shifts	X	X		• Monitor to detect species presence and absence correlated to changing environmental conditions • Create flexible multi-species permitting, licensing, and management plans • Evaluate potential and establish procedures for new commercial and recreational fisheries (e.g., establishment of catch limits, new permitting procedures) • Create international cooperative fisheries agreements
Rapid stock declines leading to collapsed fisheries	X	X		• Designate climate vulnerable species under the Endangered Species Act • Adjust quotas to help sustain stocks (e.g., reduce fishing pressure on vulnerable stocks) • Diversify fisheries and/or livelihoods
Reduced shellfish productivity and increased mortality in aquaculture facilities	X	X	X	• Monitor intake water conditions and adjust intake processes during periods of unfavorable conditions • Relocate aquaculture operations to less vulnerable areas • Develop resilient broodstock/seed for shellfish and finfish hatcheries

Climate Adaptation Toolkit for Fisheries Management



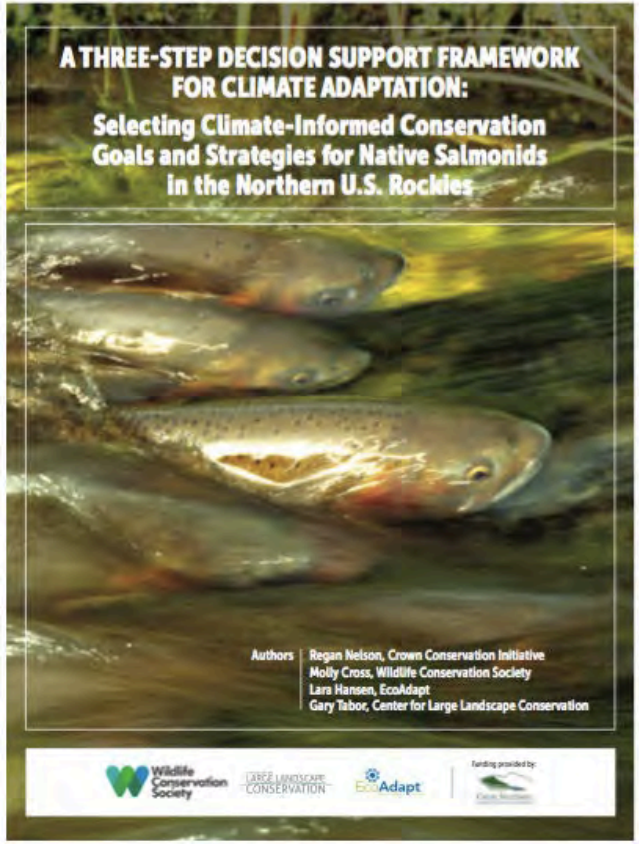
Available on CAKEx.org

Synopsis report



Supporting resources

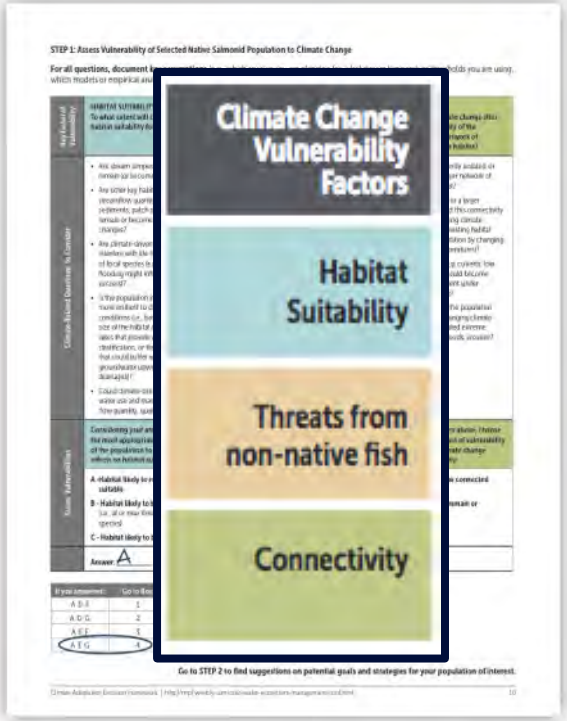
Commission for Environmental Cooperation
Rapid Vulnerability Assessment for MPAs



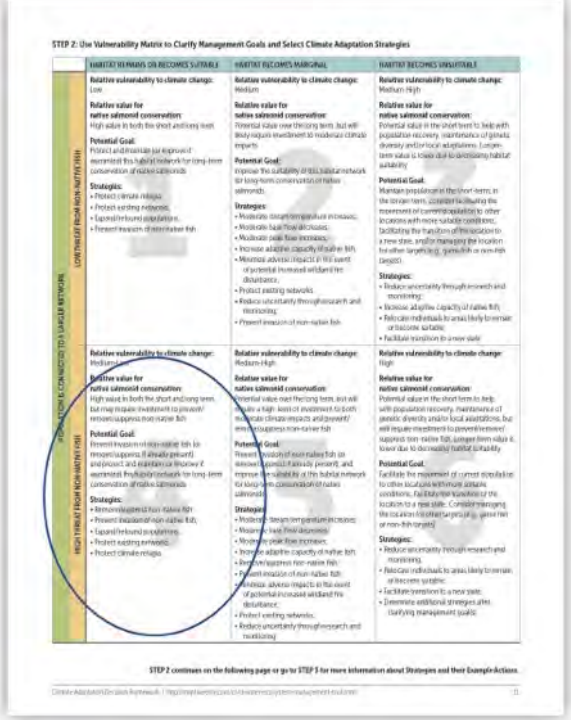
Decision Support Tool for Fisheries Management

3 Step Decision Support Framework

Step 1: Vulnerability



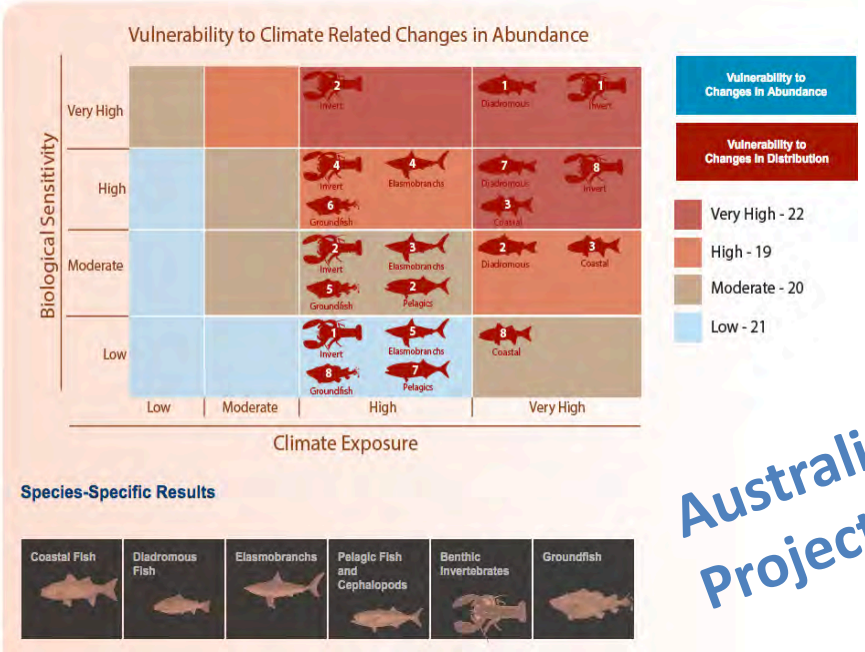
Step 2: Adaptation Strategy



Step 3: Implementation Actions

Available for download: http://rmpf.weebly.com/cold-water-ecosystem-management-tool.html

Emerging Resources



US Regional Rapid Risk Assessment Summaries

Australian Decadal Projections

New Zealand Vulnerability Assessment Summaries

Thank you

Questions: Lara@EcoAdapt.org




cake
Climate Adaptation Knowledge Exchange
CAKEx.org

Find resources

Call for proposals now open

NATIONAL ADAPTATION FORUM
ACTION TODAY FOR A BETTER TOMORROW
NationalAdaptationForum.org