



Building Climate-Resilient Fisheries

November 2020

Prepared for:

Walton Family Foundation Oceans Team and Evaluation and Learning

Prepared by:



AUTHOR ACKNOWLEDGEMENTS

Recommendations described in this *Building Climate-Resilient Fisheries Report* for the Walton Family Foundation Oceans Team and Evaluation and Learning (November 2020) do not reflect the Foundation's funding priorities going forward. They are the recommendations of the below authors only.

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SUGGESTED CITATION

EcoAdvisors (2020) Building Climate-Resilient Fisheries. Report for the Walton Family Foundation Oceans Team and Evaluation and Learning. November 2020. Pp 55. Available: <https://www.waltonfamilyfoundation.org/learning/knowledge-center>



Executive Summary

Without effective adoption of resilience-based fisheries management, climate change effects on target fish stocks threaten to undermine progress toward sustainability. In this assessment, **the EcoAdvisors (EA) team evaluated climate resilience of six fisheries:** global octopus sources to major markets, jumbo flying squid, coldwater crabs in Chile, Indonesia blue swimming crabs, finfish complexes in Mexico focused on snappers and groupers, and Alaska cod and pollock.

This suite of individual fishery systems represented several fisheries archetypes that reflect different themes in climate-resilient fisheries management, including fisheries in which:

- **stocks move across jurisdictions**, resulting in new or changing species and regulatory interactions (e.g., jumbo flying squid; Alaska cod and pollock);
- **stock abundance declines** due to environmental stressors (e.g., Alaska cod and pollock; Chile coldwater crabs); and
- **stock productivity changes** due to changes in environmental conditions, habitat, and other key species (e.g., Indonesia blue swimming crab, Mexico finfish; jumbo flying squid).

Exacerbating these challenges, **in many of these fisheries supply chains are complex, opaque, and based on vulnerable stocks** (e.g., global octopus), and in some fisheries, effective management is being undermined by climate change effects (e.g., Alaska cod and pollock).

Established principles and practices for responsible and sustainable fisheries management are generally beneficial to fisheries resilience to climate change and other stressors. However, **resilience is not necessarily achieved by managing for sustainability; core sustainability principles must be intentionally tailored and enhanced to bolster climate resilience in fisheries**, as depicted in the figure below.

First, sustainability, then resilience: How core sustainability principles in ecological, social, and technological domains can be enhanced to bolster climate resilience in fisheries

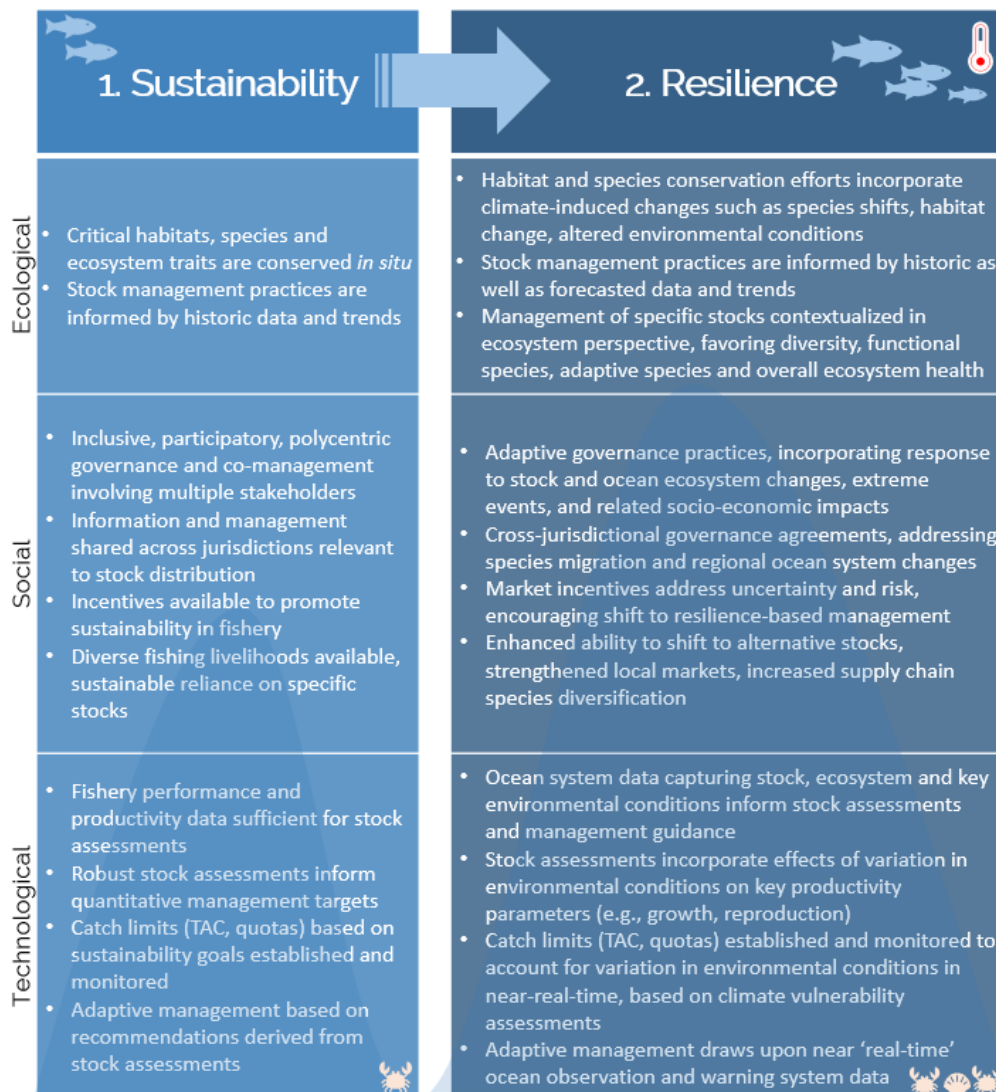
EVALUATION OF SIX FISHERIES

Octopus
Jumbo flying squid
Coldwater crabs in Chile
Indonesia blue swimming crabs
Finfish in Mexico
Alaska cod and pollock



Photo Sources: (top, center) Humboldt-squid © Carrie Vonderhaar, Ocean Futures Society; (bottom, center) Chile stone crabs © Rodrigo Fernández





For this report, **EcoAdvisors conducted a climate resilience evaluation of six fisheries to identify key climate vulnerabilities and to highlight interventions that could enhance the status of fisheries systems from sustainable toward resilient.** In particular, EA compiled information via desktop review and interviews with several experts, and then employed a resilience diagnostic framework consisting of key factors or attributes within social, ecological, and technological (SET) domains that determine a fishery system's resilience to climate change. Recommendations of essential resilience interventions for specific fisheries as well as potential portfolio-wide innovations across fisheries emerged from this analysis.

Key findings

Our resilience diagnostic framework revealed key vulnerabilities and strengths in specific fisheries as well as general resilience needs across the portfolio of fisheries.



KEY FINDINGS AMONG SIX FISHERIES EXAMINED

Ecological Domain

- Species traits are generally resilient to climate stressors
- To maintain and enhance resilience, there is a need to address climate effects on target stocks through mitigation of compounding stressors

Social & Technological Domains

- Several vulnerabilities warrant a shift to resilience-based-management
- To enhance resilience, core sustainability principles must also be implemented in priority fisheries
- To support effective management practices and promote equity goals, there is a need to promote strong, inclusive, participatory, polycentric governance and co-management

Two types of interventions needed to build resilience

- **Essential resilience interventions** are essential or emergent to reinforce existing investments and enhance resilience in fisheries
- **Portfolio-wide resilience interventions** warrant consideration for their resilience value and their broad applicability

Fishery-specific analyses revealed a common need to build general resilience with a **portfolio-wide strategy**

We observed that **among target stocks, species traits** (e.g., short lifespans, high fecundity, high physiological tolerances, high mobility) **have enabled their resilience to the present manifestation of climate stressors. To maintain and enhance this ecological resilience, we highlight the need to address and accommodate climate effects on target stocks, such as shifting abundance and distribution.** Beyond ecological measures, we **identified key social and technological vulnerabilities that reveal an urgent need to shift to resilience-based management (RbM).** Core sustainability principles—e.g., scientifically determined catch limits; secure tenure rights; inclusive, participatory, adaptive decision-making processes; multi-scale and multi-sector governance structures to ensure compliance—are essential fundamentals that need to be built upon for the resilience of WFF priority fisheries.

We summarize key findings across SET domains for the six fisheries and highlight **recommended resilience interventions.** Examples of resilience interventions that apply to one or more of the fisheries include:

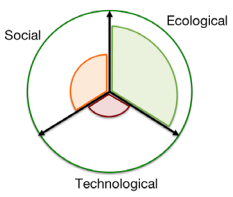
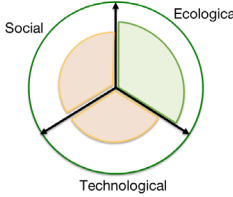
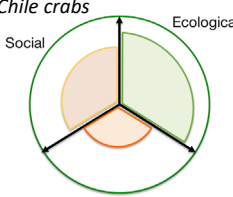
- Bolstering and expanding efforts to ensure strong, inclusive, participatory, polycentric governance and co-management to support effective management practices and promote equity goals;
- Accelerating improved, coordinated monitoring and early warning systems to support multi-jurisdictional governance and management, including adaptive harvest control rules;
- Conducting climate vulnerability assessment of target species and their habitats;
- Identifying and adapting marine protected areas and refugia;
- Promoting livelihood diversification and value-capture within and beyond fisheries;
- Updating sustainability standards and certification to include climate change and resilience considerations;
- Supporting efforts to coordinate sustainability efforts among importers to major markets.



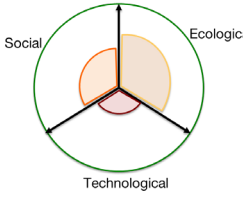
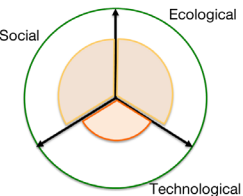
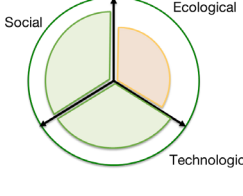
EcoAdvisor's climate resilience analysis of six fisheries highlighted key social, ecological, and technological vulnerabilities and identified specific interventions that would enhance resilience in each fishery.

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(Radar charts indicate relative resilience (increasing from center to perimeter of the circle) of social, ecological, and technological domains.)

Fishery system	Key social vulnerabilities	Key ecological vulnerabilities	Key technological vulnerability(ies)	Recommended Resilience Interventions
Octopus 	<ul style="list-style-type: none"> Weak, uncoordinated governance systems, locally to globally 	<ul style="list-style-type: none"> Unsustainable fishing pressure, including IUU 	<ul style="list-style-type: none"> Inadequate data collection and monitoring; lack of catch limits, input/output controls 	<ul style="list-style-type: none"> Bolster, expand efforts to strengthen governance Adaptive management, incorporating monitoring & data sharing Identify and implement fishing refugia/closures
Jumbo flying squid 	<ul style="list-style-type: none"> Bi-national, international governance lacking 	<ul style="list-style-type: none"> Highly responsive to env conditions; Unsustainable fishing pressure, including IUU 	<ul style="list-style-type: none"> Fishery performance and environmental data not harmonized at scale of the stock's distribution 	<ul style="list-style-type: none"> Accelerate improved, coordinated monitoring and early warning system (Humboldt Current) Strengthen multi-jurisdictional governance and management, including development of adaptive harvest control rules, possible catch/profit sharing between Peru and Chile in response to fluctuating productivity
Chile crabs 	<ul style="list-style-type: none"> Governance process has not produced guidance on performance goals and management practices 	<ul style="list-style-type: none"> Unclear climate effects; Unsustainable fishing pressure, including IUU 	<ul style="list-style-type: none"> Inadequate data collection and monitoring; lack of enforcement of catch limits, input/output controls 	<ul style="list-style-type: none"> Accelerate work of management committees Conduct climate vulnerability assessment of crab species and habitats Identify potential climate refugia for crabs as candidate no fishing zones Increase value in local markets for sustainably caught crabs



Fishery system	Key social vulnerabilities	Key ecological vulnerabilities	Key technological vulnerability(ies)	Recommended Resilience Interventions
<p><i>Indonesia blue swimming crabs (BSC)</i></p> 	<ul style="list-style-type: none"> Weak, uncoordinated governance and stakeholder coordination 	<ul style="list-style-type: none"> Unclear climate effects; Unsustainable fishing pressure, including IUU 	<ul style="list-style-type: none"> Inadequate data collection and monitoring; lack of enforcement of catch limits, input/output controls 	<ul style="list-style-type: none"> Conduct climate vulnerability assessment of BSC stocks and habitats Identify potential climate refugia for crabs as candidate no fishing zones Locally, promote diversification and value-add of other catch and capture more of supply chain
<p><i>Mexico snapper/grouper complex</i></p> 	<ul style="list-style-type: none"> Stakeholder coordination and consultation insufficient (esp Yucatán) Low incentives for sustainability 	<ul style="list-style-type: none"> Species-specific responses to warming, hypoxia; Unsustainable fishing pressure, including IUU 	<ul style="list-style-type: none"> Yucatán: Inadequate data collection and monitoring; lack of catch limits, input/output controls Gulf of California: Need to adaptively manage multi-species catch accounting for climate effects 	<ul style="list-style-type: none"> Bolster, expand efforts to strengthen governance Adaptive management, incorporating monitoring & data sharing Conduct climate vulnerability assessment of finfish spp and key habitats Identify and adapt marine protected areas and refugia Locally, promote diversification and value-add of other catch and capture more of supply chain
<p><i>Alaska cod, pollock</i></p> 	<ul style="list-style-type: none"> Remote communities potentially vulnerable; Poleward range shifts could create multi-jurisdictional issues; Sustainability certification not responsive to climate change effects 	<ul style="list-style-type: none"> Warming reduces juvenile survival Warming drives northward distribution shift 	<ul style="list-style-type: none"> Need to adaptively manage TAC accounting for climate effects, especially as species shift poleward 	<ul style="list-style-type: none"> Support efforts to improve sustainability standards by including climate change effects and recognizing resilience interventions Locally, promote diversification and value-add of other catch and capture more of supply chain



Recommended resilience interventions

Our evaluation highlighted several fishery-specific as well as general climate vulnerabilities and potential resilience interventions, based on the current resilience state of fisheries archetypes and the specific fisheries. **Recommendations are categorized as ‘essential resilience interventions’ or ‘portfolio-wide innovations and economies of scale.’** The first category refers to ‘no regrets’ actions, tools, or approaches that are essential or emergent to buttress existing investments and enhance resilience in specific fisheries. The second category includes broadly applicable interventions that are relevant across the WFF portfolio (and beyond), offering particular efficiencies and economies of scale.

Essential resilience interventions

Our analysis of specific fisheries systems and related archetypes revealed a common need to **build the general resilience of fishery systems through ‘no regrets’ actions, tools, or approaches that are essential or emergent to buttress existing investments and enhance resilience in fisheries.**

Essential resilience interventions are actions that will bolster existing investments and enhance resilience by addressing specific social, ecological, or technological vulnerabilities.

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Key Vulnerabilities	Intervention	How resilience would be enhanced	WFF fisheries that would benefit immediately from investment
<ul style="list-style-type: none"> • Ecological climate vulnerabilities not well-understood or addressed in management • No adaptive management based on environmental conditions 	Resilience-based Management planning	<ul style="list-style-type: none"> • Key climate vulnerabilities of stocks and habitats characterized, specific interventions identified • Improved stock assessments that incorporate environmental considerations • Design early warning systems using environmental data to inform management decisions 	<ul style="list-style-type: none"> • octopus • Indonesia blue swimming crab • Chile coldwater crabs
<ul style="list-style-type: none"> • Fishery system does not include spatial management of habitat or harvest to ensure sustainable productivity • Illegal, unreported, unregulated fishing depletes stocks 	Ecological interventions	<ul style="list-style-type: none"> • Climate refugia and/or fishing refugia identified and managed to bolster target stock resilience • Enhanced efforts to reduce IUU fishing improves stock resilience 	<ul style="list-style-type: none"> • octopus • jumbo flying squid • Indonesia blue swimming crab • Chile coldwater crabs • Mexico finfish complexes



Key Vulnerabilities	Intervention	How resilience would be enhanced	WFF fisheries that would benefit immediately from investment
<ul style="list-style-type: none"> • Stakeholders poorly coordinated, unclear decision-making processes • Multi-jurisdictional governance lacking for trans-boundary stocks 	Strengthening governance	<ul style="list-style-type: none"> • Established and strengthened cooperatives and fisherfolk associations • Strengthened regional fisheries management associations that clarify overlapping mandates; • Established representative multi-jurisdictional and multi-level coordination mechanisms 	<ul style="list-style-type: none"> • jumbo flying squid • Mexico finfish complexes • Indonesia blue swimming crab • Chile coldwater crabs
<ul style="list-style-type: none"> • Fishing communities depend heavily on a single stock or archetype, increasing their vulnerability to volatility in productivity and markets 	Livelihood diversification and value capture	<ul style="list-style-type: none"> • Fishing communities are able to access and serve multiple markets for their catch, can diversity target species in response to fluctuations in availability and market signals 	<ul style="list-style-type: none"> • Mexico finfish complexes • Indonesia blue swimming crab • Alaska cod and pollock

Portfolio-wide innovations and economies of scale

Beyond essential, fishery-specific recommendations, there are **several generalizable resilience interventions that warrant consideration for their broad applicability across marine fisheries**. Their broad relevance, consistency in design requirements, leveraging of existing efforts and ‘infrastructure’, and scale of execution indicate that **a portfolio-wide strategy is warranted**, as WFF may gain particular efficiencies and economies of scale. These potential (non-exhaustive) investments in innovations and economies of scale include:

- Ocean observation and monitoring
- Mobile money
- Supply chain ICT connectivity
- Updating certification systems
- Addressing perverse subsidies
- Financial innovations



Portfolio-wide innovations and economies of scale can build resilience by addressing specific social, ecological, or technological vulnerabilities in fisheries systems.

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Key Vulnerabilities	Intervention	How resilience would be enhanced
<ul style="list-style-type: none"> • Data on stock, ecosystem and environmental conditions limited in extent, quality, access, undermining informed, adaptive management 	Ocean observation and monitoring	<ul style="list-style-type: none"> • Access to improved, expanded, real-time data, analytics and forecasts enables adaptive management and responsiveness to ocean system change
<ul style="list-style-type: none"> • Fishers unable to respond efficiently to changing stock availability or productivity, limited position in supply chains. • Fishers face limited livelihood, value capture and adaptation options, exacerbating path dependency and poverty traps 	Mobile money	<ul style="list-style-type: none"> • Access to capital to allow fishers to efficiently adjust operations, capture and add value in response to changing stock availability, productivity • Strengthens livelihood diversification, adaptation and security • Potential channel for incentive-based interventions
<ul style="list-style-type: none"> • Fishers disconnected from key actors in the supply chain are unable to access information, capital, and capacity to adapt fishery management; • Supply chain fragmentation leads to inefficient, ineffective response to stressors impacting fishery production, yielding consequences across the chain 	Supply chain ICT connectivity	<ul style="list-style-type: none"> • Enhanced access to supply chain enables information sharing, access to markets, capital, networks, diversifying fishery assets and options • Supply chain connectivity strengthens overall efficiency, effectiveness and responsiveness to change, builds collective adaptive capacity
<ul style="list-style-type: none"> • Sustainability certifications do not account for efforts to enhance resilience, nor climate change effects on fishery performance • Certification systems themselves risk losing credibility and effectiveness as a market signal if climate change undermines sustainability 	Updating certification systems	<ul style="list-style-type: none"> • Certifications incentivize resilience interventions, incorporation of climate change in management targets and decisions • Certification systems themselves retain relevance in the face of climate change



Key Vulnerabilities	Intervention	How resilience would be enhanced
<ul style="list-style-type: none"> • Subsidies promote over-capacity and excess harvest, which undermines coordinated management, and • Affects the sustainability and resilience of stocks 	Addressing perverse subsidies (esp. those that support distant-water fleets)	<ul style="list-style-type: none"> • Reduce pressure on stocks • Encourage diversification • Greater scope for sustainable management enhances resilience to climate change
<ul style="list-style-type: none"> • Inefficient fishery system supply chains leave them more susceptible to volatility in production, market forces, environmental drivers • Mismatch in cashflows for investor needs • Investments in fisheries constrained by perceived downside risk, lack of previous performance history, concerns about governance 	Financial Innovations that: <ul style="list-style-type: none"> • Create the investment case and build efficiencies • Align transactional arrangements with cash flows • Manage downside risk • Incorporate uncertainty 	<ul style="list-style-type: none"> • Increased, sustained, and appropriately structured investments allow fishers to implement RbM approaches and strengthen their economic position to respond to changing stock availability, productivity • Insurance products, floor-price guarantees, other schemes help absorb negative shocks on ecological stocks and assets • Technology solutions to streamline information transfer within supply chain are identified, incubated, and commercialized to enhance efficiency and preserve profit margins



Conclusions

Core principles of sustainable fisheries management provide a solid foundation on which to build climate resilience in fisheries. However, **these principles must be adapted and expanded to incorporate climate change effects on fisheries to successfully build resilience.** Previous estimates of fisheries productivity, variability, seasonality and response to changing environmental conditions were guided by historic data, which substantiated our assumptions of a relative stable Earth equilibrium. In a changing climate, we must now understand and manage changing species behavior, stock levels, ocean ecosystems and environmental conditions, in addition to balancing the dynamic human management interventions influencing these natural systems. **Resilience-based management is about understanding and stewarding marine fisheries to thrive under change, both incremental and extreme.** EA's evaluation of climate resilience in the six fisheries identified relatively high ecological resilience in target stocks and their habitats, but several important vulnerabilities in social and technological domains. Further, our analysis surfaced several potential interventions that would address key ecological, social, and technological vulnerabilities and thus bolster resilience in specific fisheries as well as across the WFF portfolio.

This report lays the groundwork for a more extensive diagnosis, planning and investment for climate resilience in WFF's fisheries, using the resilience evaluation framework we developed, as well as more detailed inputs about individual fisheries, stakeholder perspectives, and expert assessments. Such a novel analysis would generate robust, expert-validated, and stakeholder-driven guidance for prioritizing resilience-based management interventions in fisheries within and beyond WFF's portfolio.

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