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New Study Outlines Range of Climate-Ready Options for Fisheries Managers

Ocean warming and acidification are already having measurable effects on marine ecosystems, but their implications for the future are substantially more serious. They already appear to be changing productivity, shifting populations, and damaging the carbonate shells of plankton and shellfish. To date, however, fishery managers have faced challenges in incorporating these anticipated changes into their management plans. In a recent article featured in a special issue of the journal *Oceanography*, authors Malin Pinsky and Nathan Mantua discuss eight approaches to address these problems and potentially reduce the impact of climate change on people and ecosystems. Many of these ideas are already in use, but the authors conclude that managers can greatly improve climate readiness by considering the full range of available actions.

8 adaptation approaches: A toolbox for managers

Adaptation to climate change is complex and typically requires nuanced local and regional strategies. Managers can draw from the following broad approaches in building an adaptation plan:

1. **Address cumulative impacts on marine ecosystems:** Reducing nonclimate stressors such as overfishing and habitat loss can increase fisheries' resilience to climate change.
2. **Prepare for emerging fisheries:** As the distributions of marine species across the oceans shift in response to climate change, some traditional fisheries may close and others may emerge or move into new jurisdictions. Managers can prepare for new fisheries by limiting harvest while populations establish themselves and by prioritizing research on new stocks.

3. **Account for climate in stock assessments**: Climate indicators can be incorporated directly into stock assessment models to capture the effects of environmental conditions on population growth. Alternatively, climate impact can be considered as added uncertainty.
4. **Move conservation area boundaries:** The boundaries of some conservation areas can be adjusted if the targeted species shift. Those that protect multiple species or a particular habitat, however, may need to remain unchanged.
5. **Coordinate across international boundaries:** Shifts in species distributions can create incentives for overharvest. For example, a country that is losing a fishery due to climate change may overfish the target species to compensate for the anticipated loss. International agreements can be developed or revised to prevent this from occurring, including through the trading of fishing quota across borders.
6. **Project regional climate change impact:** Global climate models can be downscaled to finer-resolution projections for specific locations, allowing comparison of future scenarios. Long-term forecasts can inform management decisions, such as which fisheries to maintain and when to prepare for ripple effects on connected businesses.
7. **Monitor ecosystems and respond quickly (real-time responses):** Ecosystem monitoring programs can enable managers to react quickly to change by, for example, adjusting quotas when fish populations increase, decline, or shift.
8. **Promote social resilience:** In general, policies that increase flexibility within the fishing industry while maintaining effective conservation measures will benefit climate adaptation. Such policies include facilitating alternative fisheries, transferable fishing quotas, and livelihood diversification.

Climate change is often perceived as a distant problem, but its effects on marine ecosystems are happening now. This article in *Oceanography* offers a useful starting place for managers to think systematically about how to help fisheries and the people who depend on them become more resilient.

Change and time scale	Ecological impact	Potential approach	Specific response	Examples
Seasonal, interannual oscillations and long-term directional climate change	Variability and uncertainty in productivity	3 Account for climate in stock assessments	Increase buffer between limits for maximum sustainable yield and total allowable catch	Proposed harvest reduction for U.S.-Canada salmon[1]
	Variability and uncertainty in productivity	7 Real-time responses to climate	Integrate ecosystem monitoring into management	Changes to quota for Bering Sea pollock[2]
	Changes in species distributions	3 Account for climate in stock assessments	Implement spatially explicit stock assessments	Spatial models for yellowtail flounder in the northeastern U.S.[3]
	Wide range of effects	6 Project regional climate impacts	Evaluate management approaches against climate scenarios	Evaluation of management options for U.S. West Coast groundfish[4]

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Change and time scale	Ecological impact	Potential approach	Specific response	Examples
Multiyear and multidecadal oscillations and long-term directional climate change	Wide range of effects	1 Address cumulative impact	Reduce subsidies and incentives for fishing overcapacity	General proposals to reduce fishery subsidies[5]
	Change in population productivity	1 Address cumulative impact	Mitigate nonclimate stressors to enhance resilience	Reduce fishing pressure on Atlantic cod;[6] mitigate damage to Pacific corals[7]
	Change in population productivity	1 Address cumulative impact	Manage for age, spatial, genetic, and temporal diversity in stocks	Balance harvest across Bristol Bay subpopulations[8]
	Change in population productivity	3 Account for climate in stock assessments	Use stock assessments with temporally variable productivity	Declining productivity in northern Alaska salmon[9]
	Wide range of effects	6 Project regional climate impacts	Rapid assessment of stock vulnerability	Climate vulnerability of Australian sharks and rays[10]
	Wide range of effects	6 Project regional climate impacts	Develop regional climate change scenarios	Atlantic croaker in the northeastern U.S.;[11] English sole in California Current[12]
Multidecadal oscillations and long-term directional climate change	Change in population productivity	3 Account for climate in stock assessments	Restrict stock assessments to current environmental regime	Recruitment variation in Pacific groundfish[13]
	Change in population productivity	6 Project regional climate impacts	Re-evaluate rebuilding goals and timeline	Feasibility of rebuilding southern cod stocks[14]
	New species shifting into a region	2 Prepare for emerging fisheries	Temporary moratorium on new fisheries	Closure of U.S. Arctic waters[15]
	New species shifting into a region	2 Prepare for emerging fisheries	Prioritize new species for research; experimental fisheries	Prioritization of North Sea anchovy for research[16]
	Difficult social and economic transitions	8 Promote social resilience	Rapid assessment of social vulnerability	Global economic vulnerability;[17] U.S. regional community vulnerability[18]
	Difficult social and economic transitions	8 Promote social resilience	Co-management of fisheries	Baja California cooperatives[19]
	Difficult social and economic transitions	8 Promote social resilience	Promote diversification of livelihoods	New fisheries for southern species in the U.K.[20]

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Change and time scale	Ecological impact	Potential approach	Specific response	Examples
Multidecadal oscillations and long-term directional climate change	Difficult social and economic transitions	8 Promote social resilience	Climate adaptation fund	Proposed endowment fund[21]
	Changes in species distributions	4 Move conservation area boundaries	Re-evaluate stock boundaries	Proposed re-evaluation of stock boundaries[22]
	Changes in species distributions	4 Move conservation area boundaries	Move closed area and management boundaries	Dynamic bycatch avoidance in Australia and Hawaii[23]
	Changes in species distributions	5 Coordinate across international boundaries	Pre-agreements, side payments, or transferable quotas	Norway and Russia transferable quotas in the Barents Sea[24]

Notes:

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