Incorporating Climate Science in Applications of the U.S. Endangered Species Act for Aquatic Species

Michelle M. McClure(11), M. Alexander(2), D. Borggaard(3), D. Boughton(4), L. Crozier(1), R. Griffis(5), J. Jorgensen(1), S. Lindley(4), J. Nye(6), M. Rowland(7), E. Seney(8), A. Snover(9), C. Toole(10), K. Van Houtan(11)

Conservation Biology 27:1222-1233. DOI: 10.1111/cobi.12166

The Challenge

Incorporating climate science into Endangered Species Act (ESA) decisions for aquatic species is challenging because: (1) the ESA does not have clear direction about many scientific aspects, nor does it consider a changing baseline; and (2) monitoring and climate studies in aquatic systems is generally scarcer than in terrestrial systems. Nonetheless, recent studies indicate that aquatic systems are at risk, and of documented extinctions for which proximate causes were identified, over half were aquatic species.

We summarize general insights and strategies for applying climate science in an ESA context derived from several case studies and the literature.

First Need: A Conceptual Model

A key first step in all conservation planning or analysis is laying out the interactions between the pieces of the system – biotic and abiotic – in a conceptual model. This should include known and suspected drivers of population status and distribution. It does not have to be complicated or quantitative, but it should cover the entire life cycle of the species in question. Such a model provides the basis for identifying important vs. lesser impacts, key needs for recovery and areas in which greater information is needed.

Listing Decisions and Large-Scale Risk Assessment

Climate will be an important factor in determining whether a species should be listed as endangered or threatened. Key considerations and approaches include:

- Assume a changing climate in projections, whether they are qualitative or quantitative
- Use plausible emissions scenarios – many previously used scenarios have already been exceeded.
- "Foreseeable future" -- trade-off between certainty in results and likelihood of detecting an effect. So:
- Multiple scenarios or time frames can be useful
    - Bracket range of potential exposure
    - Provide information about response to directional effect when timing or magnitude are unclear.
- "Significant portion of its range" – basing decisions on anticipated

[1] (1) Northwest Fisheries Science Center; (2) NOAA Earth System Research Laboratory, 325 Broadway, Boulder, CO 80305 U.S.A.; (3) Greater Atlantic Fisheries Regional Office; (4) Southwest Fisheries Science Center; (5) Office of Science and Technology; (6) School of Marine and Atmospheric Sciences, Stony Brook University; (7) Office of the General Counsel, Northwest Section (retired); (8) Erin Seney Consulting, LLC; (9) Climate Impacts Group, University of Washington; (10) Northwest Regional Office; (11) Pacific Islands Science Center. Primary contact: Michelle McClure, michelle.mcclure@noaa.gov.

range means cost of errors are not equal (e.g. if habitat is projected to be lost, but is not, this is a benefit to the species; converse is a cost to the species.)

- Limited data availability
  - Evaluate sensitivity, exposure and adaptive capacity using ecological principles (e.g. Table 1)
  - Use previous assessments as template or guide.

Long-term Planning – Recovery Planning and Critical Habitat Designation

- Three avenues for species to persist = adapt to new conditions, move to newly suitable habitat, "hunker down"
- Recovery plans offering all three approaches will have best chance of success
- Diversity as a recovery objective
  - Raw material for adaptation
  - Habitat proxies
- Spatial structure as a recovery objective
  - Allows source-sink dynamics
  - Promotes movement to emerging habitats
- May need to protect or improve currently important areas
- More robust populations currently provide a greater likelihood of persistence
- Expect to be surprised by climate
  - Strategies robust to a variety of climate outcomes (e.g. high or low precipitation) will have greatest likelihood of success

Interagency Consultations and Habitat Conservation Plans

Section 7 and related consultations are a large part of mandated ESA decision-making. Many aspects of long-term planning are also relevant for these shorter-term decisions. In addition:

- The 'environmental baseline' should presume climate change as the most likely future scenario.
- Long-term projections, even for short-term projects, will inform risk tolerance.
- Consultations should consider the action's effects on:
  - Habitat characteristic that may mitigate climate changes
  - Population characteristics important for recovery (e.g. diversity, age-structure)
  - Overall recovery goals and recovery strategy

Conclusion

- No single 'best' approach – most decisions will need a case-by-case evaluation
- Recovery plans may need to emphasize reductions in historic sources of mortality
- Shortening time frames for some consultations may provide better opportunities to adaptively manage protected species.
- Regular updates of plans, and defined triggers at decision points may help the agency deal with changing conditions
- Risk tolerance will always be an issue, and requires ongoing policy discussion at all levels.

Table 1. Characteristics of organisms and populations and mechanisms that influence likely response to climate change.

Trait	**Mechanism**	**Reference**
Dispersal potential (High mobility, broad larval distribution)	Confers resilience by reversing local extinction, colonizing newly suitable habitat	Williams et al. (2008)
Population and species level diversity	Provides adaptive capacity by promoting evolutionary adaptation	Williams et al. (2008)
Phenotypic plasticity	Confers resilience by allowing phenotypic response to environmental changes	Williams et al. (2008)
Generation time	Long generation times limit rate of demographic response to changing conditions, but might also buffer population during extreme events	Laidre et al. (2008)
Small geographic range	Increases vulnerability through greater proportional loss of current habitat, but may gain new suitable habitat elsewhere	Thuiller et al. (2005)
Habitat or niche specialization	Vulnerability from greater proportional loss of current habitat, but may gain new suitable habitat elsewhere	Thuiller et al. (2005)
Near the warm or dry edge of its geographic range	Vulnerability through greater proportional loss of current habitat	Thuiller et al. (2005)
Depends on pack ice (reproduction, resting, etc.)	Sensitivity to polar warming with little refuge	Laidre et al. (2008)