

Title

A Case Study from the Structured Decision Making Workshop

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Decision Problem

One of the issues we deal with is that we have three agencies with authority over Atlantic salmon. The management board is comprised of upper level managers from all three agencies and policy decisions are made at the regional director's level. We don't have an overall strategy for Atlantic salmon (ATS) recovery that says where we need to go so we have arguments on individual issues with no context related to overall strategy. We need an integrated strategic approach to achieve the short-term goal of avoiding extinction and the long-term goal of recovery. This includes: what would an integrated set of actions look like if we could all work together, and what are the most important actions to undertake. We need an overall strategy to choose amongst recovery tasks that best get us to recovering ATS. We're asking for a decision framework where all decision makers act in concert toward the same end goal and with a similar degree of transparency. We are all active contributors to the same goal.

Our main problem is: Choose a management strategy and a set (or portfolio) of actions to maximize the probability of ATS recovery within the budget and logistical constraints we face.

Background

Legal, regulatory, and political context

The U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) have joint responsibility for recovery of the endangered Gulf of Maine Distinct Population Segment (DPS) of Atlantic salmon (*Salmo salar*). In addition, the Maine Department of Marine Resources Bureau of Sea Run Fisheries and Habitat (SRFH; Atlantic Salmon Commission staff were moved to SRFH in July 2007, however the Commission remains as the policy setting board) is the lead entity for Atlantic salmon recovery statewide, creating a trio of agencies charged with the recovery of Atlantic salmon.

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Since the listing of the Gulf of Maine DPS of Atlantic salmon in 2000, USFWS, NOAA and SRFH (the Agencies) and partners have struggled with questions of priority and policy in choosing which recovery actions to fund annually. The Agencies often have different opinions on the significance of management actions or research and also appear to identify and weigh risks differently. Numerous documents have addressed Atlantic salmon status and recovery including but not limited to the 1995, 1999 and 2006 Status Reviews, the Recovery Plan, the State Conservation Plan, a National Research Council Report and now the SEI Hatchery Review report. To address the problems identified in these reviews, the Agencies have launched a new effort to create a single framework that lays out a united recovery strategy and an accompanying process to implement the framework.

Ecological context

Maine's Atlantic salmon population is in a critical state: fewer than 1,100 adults returned to their natal rivers in 2005, down from the recorded 18,000 commercially harvested adults in the late 1800s and less than one percent of the adults the rivers can support (U.S. Atlantic Salmon Assessment Committee 2006; National Research Council 2004). After 100 years of low adult returns, the numbers of Atlantic salmon returning to Maine rivers rose briefly in the 1970s and 1980s (Baum 1997). Unfortunately, the numbers of returning adults declined sharply in the late 1980s and early 1990s. The Gulf of Maine DPS of Atlantic salmon was listed as endangered under the U.S. Endangered Species Act in December 2000 (Department of the Interior and Department of Commerce 2000). The number of returning adults to the DPS was estimated to be only 41-110 in 2005 (U.S. Atlantic Salmon Assessment Committee 2006). The reasons for the decline in the population are complex. Key factors are poor quality of the freshwater environment, including degraded fry habitat, lack of over-wintering locations for large parr, and marginal holding areas for adults, as well as poor marine survival (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2005; National Research Council 2004; Kircheis 2001; Maine Atlantic Salmon Task Force 1997).

Decision Structure

Alternative actions

For the rapid prototyping we describe in this report, we chose to look at four 'typical' recovery actions among the much larger set of possible actions.

Prototype Actions:

- Fish Passage - Lower Penobscot Dam
- Riparian Buffers - 3 rivers w/passage
- Adult Stocking - Narraguagus River
- Smolt Stocking - Sandy River

Objectives

We decided to start with looking at the objectives after realizing that they must be the foundation of a unifying strategy. For our first prototype, we identified four potential objectives that define 'recovery' for the ATS. We debated, however, whether or not we were talking about one fundamental objective (numerical persistence) and three "means" or intermediate objectives

(conserving genetic diversity, distribution, and ecosystem functions), or whether these are all fundamental objectives with potentially different degrees of importance or weights.

Prototype Objectives:

- Maximize the likelihood of a greater than or equal to 95% probability of persistence of the DPS in the wild over 100 years
- Maximize the probability of maintaining genetic diversity
- Maximize the probability of maintaining populations in all of the currently occupied rivers (distribution)
- Restoration of ecosystem functions (we added this as an objective during the decision analysis)

Constraints: funding, people, number of fish available for projects (e.g., research or stocking), expertise

Predictive model

A PVA population model has been developed for Atlantic salmon and additional modeling work is underway. For our class exercise we used expert judgment to develop the numbers used in a prototype consequences matrix. In a real life example we realize that additional salmon experts and modelers will work with us to develop the numbers. Ideally we would have a working version of the PVA that is easily modified, have few parameters, and is able to assess the consequences that the group needs. We won't need a new model if we can use the existing PVA model.

Decision Analysis

Given our uncertainty in how to frame the problem and objectives, we explored two different decision making structures. First we focused only on a single objective of persistence probability to rank actions by potential benefits per cost. When we realized that a simple cost-benefit assessment on this single objective was not capturing the problem appropriately, we switched to investigating methods that looked at tradeoffs among multiple objectives to identify optimal recovery actions. Here we report on this second prototype using multiple objectives.

We developed a consequences matrix to assess the four actions (passage, riparian buffers, adult stocking, and smolt stocking) against three objectives (population persistence, distribution, genetic diversity). While constructing the matrix, we realized we were missing an objective of ecosystem processes. For this rapid prototype, we filled the matrix with hypothetical performance values since we lacked the relevant data or model outputs (e.g., from the salmon PVA model currently in development). We assumed the four recovery actions we identified for the prototype exercise had equivalent costs so that cost/benefit was not a consideration in this exercise, recognizing that in future application that dimension will need to be added to the decision structuring along with logistical constraints. The consequences matrix allowed us to determine quickly whether any of the actions could be eliminated because they are 'dominated' by the other alternatives, in other words lower performing than one or more of the alternatives on all of the objectives such that it could not be an optimal choice no matter how the objectives were weighted. This kind of preliminary screening helps reduce the decision problem to a smaller set of top contending alternatives.

Next we applied the SMART method to the consequences matrix, by converting the performance measures on every objective to normalized 0-1 scales and adding weights, or relative importance, to each of the four objectives. SMART rankings for each action are the simple weighted sum of the alternatives' performance values. We looked at weighing the various objectives evenly and differently as a type of sensitivity analysis. The SMART table (in an Excel spreadsheet) allowed us to easily adjust the weights of objectives and determine the influence on the action rankings. We also explored sensitivity analysis by altering the values for some of the actions in the matrix. In the consequences matrix (Table 1), below, adult stocking was dominated by smolt stocking, so we removed this action from further consideration. In the SMART table (Table 2) we weighted the population persistence objective (.7), much greater than the genetic diversity (.1), distribution (.1), and ecosystem function (.1) objectives. As a result, fish passage was the highest scoring action in this hypothetical case.

Uncertainty

In this exercise, we addressed some of the uncertainty about the future impacts of the four actions by using probabilistic performance measures for two of the objectives: population persistence and river occupancy. For genetic diversity and ecosystem function we assumed fixed performance, without considering uncertainty about those objectives for this prototype. Future applications can expand the treatment of uncertainty through sensitivity analysis, that is, by varying the performance values across reasonably likely ranges, running the population and SMART models and evaluating how this affects the outcome. For example, some values could vary widely, but have little effect on the decision outcome.

Discussion

Value of decision structuring

We believe that structured decision-making has the following advantages:

- Participatory
- Transparent
- Pragmatic
- Science based
- Strategic versus opportunistic
- Reveals sources of disagreement
- Measure if you are getting to your objectives
- Keep focus on objectives
- Better allocation of resources
- Predictable therefore will lead to better designed projects
- Common ground
- Proactive versus reactive
- Explicit
- Logical

Up to now, decision-making for salmon recovery has been opportunistic (shotgun approach). Salmon recovery lacks a common strategy for decision-making. Decisions were often not linked

to objectives. This sometimes led to a feeling of being ineffectual. It is difficult to be strategic without commonly defined and measurable objectives. It is difficult to achieve buy-in on decisions when objectives aren't transparent. This sometimes leads to mistrust between stakeholders. Decisions were sometimes perceived as being inconsistent, and we lose credibility.

Further development required

After completing training at NCTC our goal is to adopt an SDM process for the three agencies working on Atlantic salmon recovery. We all acknowledge "Difficult Decisions Need to Be Made". We plan to promote structured decision making by implementing the following activities:

- Immediately write a memo to USFWS, ASC, and NOAA management and technical team
 - Insights and why we seem to be struggling – we see a path and that it is essential to adaptive management – AD is a form of SDM - expertise
- Brief management for each of the three agencies of what SDM is and what we accomplished at NCTC
- Brief supervisors on strengths and weaknesses of process compared to alternatives
- July 24 and 25 meeting – propose an agenda that allows us to introduce the results of our work at NCTC
- Fall – organize workshop to address adaptive management and structured decision making
- Seek outside expertise to help lead three ATS agencies through a structured decision making process

Prototyping process

We started the first day with a narrow problem definition and realized that we needed to back up and look at the broader picture, especially to define our objectives in clear and measurable terms before tackling a smaller problem. We thought initially that we were dealing with a single objective when we were really dealing with multiple issues that need to be addressed.

We hit several points where we didn't know how to move ahead – but we recognized when we were having trouble and asked for help. We went into the weeds a lot but needed to go there as part of the process. The process wasn't a straight line but we don't feel as though we took wrong turns. We definitely needed help from the consultants to find our way back.

Recommendations

We believe one of the most important steps is to revisit recovery objectives. Which are fundamental objectives? Which are means objectives? How can we get stakeholders on a common page with terminology related to goals and objectives? Will the group accept one common metric (i.e. probability of population persistence) that will become the basis for evaluating future decisions or will we adopt multiple objectives for future decisions (i.e. diversity, distribution, ecosystem function). How will the group weight the importance of multiple objectives?

Once there is agreement on the problem, objectives, and relative importance of objectives, then we can begin constructing models to help determine which actions should be priorities for recovery. Constraints of budget, staffing, and availability of fish will also have to be addressed

in the decision structuring. Salmon experts and PVA models will provide inputs for the decision model (SMART method or other approach) that are as accurate as possible and include uncertainty measures. Expert consultants will be employed to assist the group in choosing or developing appropriate tools/models. Facilitators will help keep the group on task. Models will be tested using sensitivity analyses and adjusted accordingly. Completed models will be used to guide funding, hatchery, and personnel decisions. Models will be incorporated into an iterative adaptive management process. Research projects will be considered as a means to evaluate priority areas of uncertainty. Models will be revisited and revised periodically (every 3 to 5 years) in an adaptive process employing new information, research results, etc.

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Tables

Table 1. Consequences Matrix (performance values, in 100 years). Shading indicates the dominated alternative (outperformed by other actions on every objective).

ACTION	OBJECTIVE			
	Population Persistence (% probability)	Heterozygosity (Avg)	All Rivers Occupied (% probability)	Ecosystem Function (Index)
Passage at Lower Penobscot Dam	30	.35	.8	10
Riparian Buffers on 3 Rivers	15	.4	.8	30
Adult Stocking on Narraguagus R	5	.3	.9	0
Smolt Stocking on Sandy River	15	.3	1	0

Table 2. SMART Table (normalized performance measures, 0-1 scales)

ACTION	OBJECTIVE				RANK
	Population Persistence (% probability)	Heterozygosity (Avg)	All Rivers Occupied (% probability)	Ecosystem Function (Index)	
WEIGHT:	.7	.1	.1	.1	Weighted Sum
Passage at Lower Penobscot Dam	1	.5	0	.3	.78
Riparian Buffers on 3 Rivers	.4	1	0	1	.48
Smolt Stocking on Sandy River	.4	0	1	0	.38