Non-Epistemic Values in Adaptive Management: Framing Possibilities in the Legal Context of Endangered Columbia River Salmon

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Abstract:

Courts have determined that adaptive management does not satisfy the Endangered Species Act's requirement to use the "best available science." This is due, in part, to the failure to recognize the role of non-epistemic values in science. We examine the role of values in the legal controversy over the scientific reports and adaptive management plans for endangered salmon in the Columbia River Basin. To do this, we employ philosophical concepts related to risk and uncertainty that demonstrate how non-epistemic values are internal to science. We describe how, because adaptive management is a method for dealing with inductive risk, by remaining flexible, responsive, and adaptive in those circumstances where the costs of making a mistake are very high, it requires special attention to ensure that it remains useful. We conclude that, because non-epistemic values will inevitably influence the "best available science," it is critical that they are clarified in any adaptive management planning so that we can ensure the salmon conservation that the ESA mandates. Fortunately, because adaptive management is iterative in nature and includes opportunities for engagement between policy-makers and scientists, it enables clarification of non-epistemic values through making standards of evidence transparent, acknowledging aims and goals, and dealing with uncertainty at the institutional level.

Keywords: adaptive management, social construction of risk, science-policy interface, conservation management

1.0 Introduction

In a river system such as the Columbia River that is highly altered by hydropower and climate change, salmon survival and recovery is categorically uncertain. The Endangered Species Act (ESA)—the federal statute designed to prevent the extinction of plants and animals—contains conflicting requirements regarding uncertainty. It both recognizes and addresses it, by incorporating the precautionary principle and relying on the "best available science," and it also ignores it, by failing to address the specific uncertainties embedded in the "best available science" and where mitigation measures thus may not work. Yet scientists, managers, and the courts must find a way to deal with this uncertainty and utilize the "best available science" in order to take action to address imperiled species in a timely way. One solution to this problem has been to incorporate an adaptive management strategy that implements mitigation as it determines the success of that mitigation action. This approach attempts to address uncertainty by adapting to changing conditions and learning from previous efforts. As adaptive management comes to reflect the best available science, non-epistemic values—such as social, political, or ethical values—play a vital role in determining what science is available to use in decision-making. Yet in the salmon mitigation context, federal courts must recognize and accept the role of non-epistemic values in scientific practice—particularly as they relate to addressing uncertainty in adaptive management—to ensure that what is understood as the "best available science" is in fact the science most likely to promote effective actions that meet the goal of salmon conservation.

While adaptive management is used to resolve tradeoffs and make timely decisions, it has also been accused of "kicking the can down the road," as decisions about sufficient evidence and levels of tolerable risk are ignored and deliberated at a later time (Ruhl and Fischmann, 2011). Appearing to agree with this criticism, federal courts have to date rejected adaptive management approaches to address threats to ESA-listed fish in the Columbia River because the plans have lacked specific mitigation that is "reasonably certain to occur"—adaptive management, by its nature, delays the development of any mitigation (effective or not) to a later date. While it may seem initially that this inability to adopt flexible, effective mitigation strategies is an unintended consequence of the ESA's strict statutory requirements, we argue that it is instead a result of the inability of both scientists and the courts to recognize the role of *values* in both the practice and implementation of science. Non-epistemic values—including acceptable levels of risk, the precautionary principle, the cultural or social importance of salmon, and the desire for affordable non-carbon hydropower—all influence the questions scientists ask, the methods they use to answer those questions, the certainty and nature of their conclusions, and the ultimate on-the-ground implementation of the knowledge acquired.

Instead of trying to eradicate values from science, many science studies scholars have suggested that it may be more useful to be clear about where and how values play a role within science itself (Elliot and Resnik, 2014; Douglas, 2000; 2009). This article is based on the argument that—for reasons that will be explained—non-epistemic values cannot be eradicated from science. While values are often understood as having no place in science, the end of the "value-free ideal" has been well established by philosophers of science (Kuhn, 1977; Douglas, 2000, 2009; Kournay, 2010), feminist scholars (Haraway, 1989; Longino, 1990), pragmatists (Brown, 2012; James, 1970 [1896]), and beyond. They have provided new ideals such as those of a "socially responsible science" (Kournay, 2013), offered frameworks for managing social values within science (Douglas, 2009; Elliot, 2013; Longino, 1990), and explored the ethical implications of this (Steel and Whyte, 2012). Crucially, these theoretical developments have enabled scientists to better understand their role in policy-making (Pielke, 2003). While debates about the nature of knowledge and the role of values in science have been useful in understanding the production and application of knowledge, they are often separate from discussions about environmental law and adaptive management, where the desire to draw a distinct line between science and policy is often a common theme.

The legal controversy over the effects of dam operations on endangered and threatened salmon, as considered in the Federal Columbia River Power System (FCRPS) Biological Opinions (BiOps),[1] provides a unique example of an enduring conflict at the nexus of science,

[1] The Federal Columbia River Power System includes thirty one federally owned hydropower dams on the Columbia and Snake rivers, as well as the federally owned transmission system that distributes power from these dams.

law, and adaptive management. While scholars have analyzed this controversy in multiple ways, in this article we extend and complicate that previous work by clarifying the role of non-epistemic values in science in order to better understand science-policy controversies, particularly those concerning adaptive management. This understanding explains why scientifically-based management plans continue to be questioned and remanded by courts even though adaptive management is being applied in increasingly sophisticated ways. It is therefore important to open up the "black box" of non-epistemic values in science—enabling a more transparent and democratic solution to complex environmental management problems.

We begin by briefly outlining the controversy over the FCRPS BiOps in the Columbia River and explain how adaptive management has been repeatedly rejected by the courts. We then discuss how non-epistemic values play a role in both the "internal" practice of science and in determining what science is available for decisionmakers. We do this by exploring two philosophical arguments concerning when to draw inference—the argument from inductive risk and pragmatic encroachment. We then explain how understanding and explicating these values when employing adaptive management can help avoid some of the conflicts over science in the courts. We conclude that, because non-epistemic values will inevitably influence the "best available science," it is critical that they are clarified in any adaptive management planning so that we can ensure the salmon conservation that the ESA mandates. Fortunately, because adaptive management is iterative in nature and includes opportunities for engagement between policy-makers and scientists, it enables clarification of non-epistemic values through making standards of evidence transparent and articulating aims and goals, while also dealing with uncertainty at the institutional level.

2.0 Adaptive Management in the Courts

The thirty-one dams on the Columbia and its tributaries have transformed the social, cultural, and ecological relationships in the region in complex and contentious ways. While the Pacific Northwest's economy may have benefited from this relatively inexpensive, renewable, and federally-owned energy source, the dams have irrevocably altered the ecosystem and devastated anadromous fish populations (Worster, 1985; Taylor, 1999). There are currently thirteen salmonid species (salmon and steelhead) listed under the ESA as either endangered or threatened, each one having complex life cycles, with many migrating up to hundreds of miles downstream to the ocean, and then after two to six years, returning those same miles upstream to spawn.

Although the main impact from dams was originally thought to be as barriers to upstream migration, they negatively affect downstream migrations as well— increasing water temperatures, lengthening downstream migration times, increasing exposure to predators, causing rapid fluctuations in oxygen levels, and physically injuring and killing fish through contact with dam infrastructure (Taylor, 1999). Additionally, the Columbia River dams have caused substantial social and cultural harm as reservoirs flooded locations of important cultural and spiritual significance to the Native American tribes in the region, including traditional fishing and gathering sites. The reduction in salmonid populations deprives tribal communities of a foundational "first" food, a critical cultural resource, and potentially violates treaty rights and the Federal Trust responsibility to the tribes (Pearson, 2012; Barber, 2005). In addition to the ESA's mandate to recover listed species, these treaty rights are an important facet to the complex relationships between law and science aimed at salmonid recovery in the basin.

2.1 The BiOp Controversy

All dams in the FCRPS are managed by one of two federal agencies: the Bureau of Reclamation (BoR) or the U.S. Army Corps of Engineers (Corps). A third federal agency, the Bonneville Power Administration (BPA), markets the power produced by the FCRPS. Dam management therefore constitutes a federal action subject to requirements of federal law, including—among others—the ESA. Section 7 of the ESA provides that all federal agencies must ensure that their actions not jeopardize the continued existence of a species listed as threatened or endangered, nor result in the destruction or adverse modification of its "critical habitat." These action agencies satisfy the Section 7 requirements through a process known as "consultation" with the appropriate federal fish and wildlife agency, either the Fish & Wildlife Service for terrestrial species or NOAA Fisheries for marine species and anadromous fish (including Columbia River Basin salmon and steelhead).

Where it is determined that an action is likely to adversely affect a listed species, or is likely to result in the destruction or adverse modification of critical habitat, the appropriate wildlife agency prepares a "biological opinion"(BiOp) as to whether the action will result in jeopardy or adverse modification. If the agency determines that jeopardy would result, either the action cannot proceed without violating Section 7 or the action agency must implement "reasonable and prudent alternatives" (RPAs) to the action in order to avoid jeopardy.

After NOAA Fisheries (then known as the National Marine Fisheries Service) listed the first salmonids in the Columbia River Basin as threatened in 1991 and 1992, the BoR, Corps, and BPA initiated consultation with NOAA Fisheries to determine the effects of dam operations on these species. In the years following, NOAA Fisheries listed ten additional Columbia River Basin anadromous salmonids as threatened or endangered, which required additional consultations to determine the effects of dam operations on those listed species.

Including the initial consultation in 1992, NOAA Fisheries has completed eight BiOps on the effects of dam operations on Columbia River Basin salmonids.[2] Various interest groups have challenged all eight, alleging an array of legal problems with the opinions. All of the BiOps since 2000 have been found to violate the ESA, and it is the controversy over those BiOps that is the focus of this article.

In the 1990s, NOAA Fisheries completed three BiOps and three supplemental BiOps, initially analyzing the effects of the FCRPS on just three listed species, and further supplementing as more species were listed. All three BiOps were challenged, due to failure to consider worst-case assumptions or "spreading the risk" through modeling in order to find "no jeopardy" (*AR* v. *NMFS,* 1997). Although the plaintiffs claimed that the BiOp used "overly optimistic modeling," the Oregon District Court deferred to NOAA's scientific judgment. It was not until the 2000's, however, that NOAA Fisheries completed a new BiOp to consider the effects of dam operations on the species that had been listed since completion of these previous analyses. That opinion determined that continued operation of the FCRPS would jeopardize the continued existence of eight listed species, but identified an array of RPAs it believed would avoid jeopardy. These RPAs included population performance standards for each species, operational requirements at the hydro facilities, offsite mitigation, short- and mid-term rolling plans, comprehensive check-ins, and monitoring and evaluation, among others.

A group of conservation organizations, supported by the state of Oregon and several of the region's Indian tribes, challenged the 2000 BiOp on multiple grounds. Judge James Redden, who would continue to hear challenges to the FRCPS BiOps for the following decade,

[2] In 1992, 1993, 1995, 2000, 2004, 2008, 2010, and 2014. The 2010 and 2014 BiOps are characterized as supplements to the 2008 BiOp.

determined that NOAA Fisheries' no-jeopardy determination was arbitrary and capricious[3] on two grounds. First, that the agency used a geographic definition of "action area" that was unreasonably narrow, including analysis of only the immediate area affected by FRCPS actions (the mainstems of the Columbia and Snake Rivers), rather than the larger range-wide area "where the impact is perhaps less direct but no less certain to occur" (*NFW* v. *NMFS,* 2003). And second, Judge Redden determined that the agency, in reaching the no jeopardy determination, improperly relied on actions, such as riparian habitat restoration and protection that *were not reasonably certain to occur*. This issue would return in later BiOps.

2.2 Adaptive Management in the BiOps

In order to deal with uncertain conditions while at the same time addressing the need to protect endangered species in a timely way, many natural resource agencies have embraced adaptive management. Adaptive management is an attempt to deal with scientific uncertainty while still making decisions by continually revising management actions in light of new knowledge and experience (Holling, 1978; Walters, 1986). In 1993, Kai Lee, an academic and former board member of the Northwest Power and Conservation Council, explored the interface of science and policy in the Columbia River in his book *Compass and Gyroscope*. He described a need for both adaptive management and political deliberation. Managers and scientists who were eager to explore the possibilities and nuances of incorporating adaptive management into policy-making welcomed this contribution and sought ways to incorporate adaptive management into planning and policy in the region (Lee, 1993).

[3] "Arbitrary and capricious" is the standard federal courts use when considering challenges to administrative decisions. It a commonly-used shorthand for the full standard found in 5 U.S.C. §706.

After the Bush Administration's failed effort in the 2004 BiOp to exclude the dams themselves from the analysis of impacts to listed salmon,[4] NOAA Fisheries tried a new approach. Although adaptive management has been both explicitly and implicitly used throughout the BiOps and the operation plans for the river, it did not become an explicit legal issue until the 2008 BiOp. The revised 2008 BiOp attempted to remedy many of the problems with previous BiOps by providing funding for habitat restoration and mitigation options such as hatchery and transportation that were reasonably certain to occur, at least in the short term. While reviewing the 2008 BiOp, NOAA Fisheries created an Adaptive Management Implementation Plan (AMIP) designed to implement the RPAs more effectively in an adaptive management framework. While a challenge to the 2008 BiOp was pending before Judge Redden, the agency requested a stay of the proceeding and a remand to allow it to incorporate the AMIP into the BiOp. The agency issued a supplemental BiOp with the AMIP in December 2010.

Unlike previous BiOps, the 2008/2010 BiOp included specific mitigation projects and funding for the first five years of its ten-year lifespan (i.e., 2008-2013). After 2013, the agencies would rely on the monitoring and studies in the AMIP to determine what mitigation to implement for the second five-year period. Because it would develop them based on the experiences of the first five years of its lifespan, the BiOp could not identify what the future actions or projects would be. Nor given the inherent uncertainty of the effectiveness of restoration and mitigation efforts, could it ensure that *effective* projects could even be created. Consequently, although he agreed that the 2008/2010 BiOp satisfied the ESA's requirements for the 2008-2013 period, the lack of mitigation that was "reasonably certain to occur" for the 2013-

[4] The 2004 BiOp is not relevant to this conversation, given its radically different approach. In that BiOp, NOAA Fisheries determined that because it did not have the authority to remove the dams, they should be considered as part of the environmental baseline, and thus the impacts of the dams themselves would not be considered in determining whether continued operation of the FCRPS would jeopardize the listed species. Unsurprisingly, this approach was rejected by Judge Redden.

2018 period rendered that aspect of the BiOp arbitrary and capricious. This highlighted a problem with incorporating adaptive management into an ESA recovery plan: for the judge, the second five-year period and the adaptive management measures were simply a "promise to figure it all out in the future" (*NWF v. NMFS,* 2011). At least as applied in that BiOp, Judge Redden identified a danger in substituting adaptive management, and the uncertainty inherent in that approach, for substantive decision-making and planning, and concrete, specific mitigation projects.

In May 2016, after Judge Redden retired, a new judge remanded the 2014 Supplemental BiOp created in response to Judge Redden's remand of the 2008/2010 BiOp. The 2014 BiOp failed in part because it did not "properly analyze the effects of climate change," and because it was "inconsistent" in its "treatment of uncertainty" (*NWF v. NMFS,* 2016). In his order, Judge Simon recognized this as "picking and choosing" between which uncertainties to emphasize, something that has discredited science in other contexts (Herrick and Sarewitz, 2000). While adaptive management was once seen as a way to deal with uncertainty, the level of uncertainty within these BiOps proved too much for the court, even when part of a formal adaptive management plan.

2.3 Court Refusal of Adaptive Management

Despite its ambitious goals and theoretical value, adaptive management has often failed in practice, as in the case outlined above. Natural resource scholars have interrogated adaptive management and found that time and again, adaptive management fails to deliver on its promises to balance uncertainty and action in natural resource management (Blumm and Paulsen, 2013; Volkman and McConnaha, 1993; Ruhl and Fischmann, 2011; Doremus, 2001). The problems with adaptive management, uncertainty, and risk become especially clear in the story of the intense litigation over the BiOps for endangered and threatened salmon recovery (Morse, 2012; Doremus, 2001; Blumm and Paulsen, 2013; Blumm, Thorson and Smith, 2006; McLain and Lee, 1996). Critics of NOAA Fisheries' efforts to implement adaptive management have dubbed it a "watered-down" version of the principle that is more like "ad hoc contingency planning" than "learning by doing" (Ruhl and Fischmann 2011: 426). Other observers were even more critical, calling the agency's efforts outright "deception," claiming the agency misused scientific authority in the form of adaptive management to convince the public that recovery and restoration are taking place, when in fact they are not (Blumm, Thorson and Smith, 2006).

Given its lack of specificity, Judge Redden rejected the 2010 BiOp saying that it was "simply [a] promise to figure it all out in the future" and "neither cautious nor rational" (*NWF v. NMFS,* 2011). The most recent 2016 Court Order (*NWF v.* NMFS, 2016) was clear in its judgment of how uncertainty was used in the BiOp to bolster some arguments, and not others, stating that "where uncertain information *supported* NOAA Fisheries' no jeopardy conclusion, NOAA Fisheries relied on that information," and "conversely, where information was uncertain but may *not* have supported NOAA Fisheries' no jeopardy conclusion, NOAA Fisheries disregarded or discounted it, including effects of climate change" (pp. 110-11).

In developing a scientific basis for the adaptive management plan, NOAA Fisheries had to make decisions about standards of evidence for drawing inferences and the acceptable levels of uncertainty in any substantive conclusion. As we will describe, these decisions require consideration of non-epistemic values. Because the ESA requires the use of the best available *science*, the court's rejection of these non-epistemic, and thus "non-scientific," values as integral parts of NOAA Fisheries conservation efforts has damaged the credibility of adaptive management and the science itself. The credibility of adaptive management could be restored by clarifying values, instead of hiding under a veil of scientific objectivity (Wagner, 1995). Decisions relating to risk should be addressed directly and transparently, not put off to a later date under the guise of adaptive management (Ruhl, 2011). This matters because of the damage that is done to scientific credibility through the politicization and de-legitimization of science in the courts (Brown, 2015).

3.0 Addressing Uncertainty in the ESA

The ESA and its use of the precautionary principle have changed the way that judges deal with uncertainty (Jasanoff, 1995). The ESA itself is necessarily founded on values, and is largely a statement about the inherent value of the non-human natural world without reference to human benefit.[5] As articulated by the U.S. Supreme Court in Tennessee Valley Authority v. Hill, the plain goal of the ESA is to stop extinction "whatever the cost," and it embodies the precautionary principle within its legal requirements. Section 7, the provision at issue in the salmon cases, requires that federal agencies ensure that all actions not jeopardize the continued existence of listed species. The burden is therefore on the agency to demonstrate *no* jeopardy prior to undertaking an action, rather than on the public or other opponents to demonstrate jeopardy will occur if the action proceeds. Yet by delaying concrete actions, adaptive management can also be used to disguise political trade-offs and risks, and it can prevent the use of the precautionary principle as we wait for certainty from better science (Ruhl and Fischmann, 2011). This is important because the ESA mandates the use of the "best available science," and federal agencies thus must rely on agency scientists to make this judgment, even in light of the

[5] There are two exceptions to this idea. First, the ESA excludes from its provisions "species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this chapter would present an overwhelming and overriding risk to man." 16 U.S.C. §1532. And second, following the decision in TVA v. Hill, Congress amended the Act to create the "God Squad," a group of a top level government officials who can, under specific circumstances related to benefits of a particular proposal, allow an agency action to, in effect, cause a species to go extinct. 16 U.S.C. §1536.

precautionary principle. In other words, levels of precaution are best understood as co-produced by both scientists and the courts (Jasanoff, 1995).

On the surface, the legal requirements to use the best available science, and to rely on mitigation that is "reasonably certain to occur," appear to be means of addressing uncertainty. However, the "reasonably certain to occur" standard only describes the likelihood that mitigation efforts will be implemented, not their likelihood of success. These different understandings of certainty therefore fail to address the difference between a *plan* that may be reasonably certain to occur, and whether or not a mitigation *outcome* or *effect* is likely to occur, as inferred from the best science available. The reasonably certain to occur standard fails to recognize that whether or not these actions will *have the desired effect* and in fact conserve salmon populations is a risk that must be inferred using non-epistemic values. .

While adaptive management is one attempt to address this issue by acknowledging and planning for the potential failure and subsequent reimagining and improving of mitigation efforts, it has thus far been rejected by the court. We argue that this is due to the inability to recognize non-epistemic values at multiple locations within science and to understand how they interact within adaptive management. Revisiting adaptive management by conceptually locating the role of values within it is therefore warranted. The following sections explore how an understanding of non-epistemic values in science, including inductive risk and pragmatic considerations, can help explain why adaptive management remains a source of conflict at the interface of science and law.

3.1 The Consequences of a Mistake

Across the BiOps and court decisions analyzing them, it is clear that both the agency and the courts have struggled with how to deal with high levels of uncertainty through adaptive management. Much of the academic discussion about the BiOps involves delineating between science and policy (Ruhl, 2007; Ruhl and Salzman, 2006), or clarifying where decisions based on science are actually policy decisions (Doremus and Tarlock, 2005)—what Wagner (1995) refers to as areas of "trans-science." Yet conceptualizing the role of values within science itself can potentially decrease conflict over the validity of science, increase scientific credibility (Elliot and Resnik, 2014), and reclaim adaptive management as a useful tool (Rist et al., 2013).

While keeping social and ethical values out of scientific practice has been, in part, a project to protect the objectivity and therefore the credibility of science, Douglas (2000; 2009), Steel (2010), Longino (1990), and others have explored roles for non-epistemic values that do not threaten the epistemic integrity of scientific work. For instance, Longino (1990) articulated three relevant points where non-epistemic values can influence decisions: decisions about what to study, the application of scientific knowledge to society, and ethical decisions about methods. In another framework, Douglas (2009) provides an alternative ideal for values in science, in which non-epistemic values can play either a "direct" or an "indirect" role in decisions, such as which topics to study, methods to use, or assessing evidential sufficiency or the acceptable level of certainty with which a conclusion may be drawn. Within the lab or the field, non-epistemic values influence methodological choices, acceptable levels of statistical significance, and which models or combinations of models will be used—all of which affect the regulatory policies that result. These non-epistemic value judgments, including "how long one waits before drawing an inference," or judging the severity of an error, hinge on the argument from inductive risk (Steel, 2010: 25) as well as pragmatic considerations such as pragmatic encroachment.

Because the ESA deals with the potential extinction of a species, it requires a management approach that explicitly recognizes and addresses the potentially irreversible consequences of making a mistake. While all scientific conclusions contain some potential for error, known as inductive risk, the consequences associated with the risk of "being wrong" varies depending on societal values. Adaptive management is, fundamentally, a method for accounting for both inductive and societal risks by remaining flexible, responsive, and adaptive, especially in those circumstances where the costs of both making a mistake *and* not taking action are very high. We aim to demonstrate that by making these risks transparent in adaptive management planning, we can minimize conflict over science-based policy decisions and clarify uncertainties in both knowledge and action. This can be done by understanding how non-epistemic values become a part of the scientific process through the argument from inductive risk and a closely related concept—pragmatic encroachment.

3.2 The Argument from Inductive Risk

Since the 1950s, the argument from inductive risk has challenged the value-free ideal for science (Hempel, 1965; Rudner, 1953). Inductive risk is the risk that a scientific conclusion might be wrong, and the argument from inductive risk describes how scientists must use judgment about whether to accept or reject a hypothesis. Scientists consider what evidence and confirmation will be needed to make inductive risk acceptable as well as evaluating the consequences of the error (Douglas, 2000). As Douglas states (2000), "where non-epistemic consequences follow from error, non-epistemic values are essential for deciding which inductive risks we should accept, or which choice we should make" (Douglas, 2000: 565). Because there is always a risk in being wrong, non-epistemic values such as those based on the consequence of being wrong, including ethics and risk tolerance, must therefore be a factor in choosing to accept or confirm a hypothesis (Hempel, 1965; Rudner, 1953). This means that in some instances the level of certainty that is required for accepting a hypothesis may be higher than for others, where the seriousness of the mistake in accepting or rejecting a hypothesis is judged by the scientist to be high—for example, where there is a risk of toxic exposure to the public should the decision be wrong (Douglas, 2000). Since no hypothesis is ever certain, the judgment of whether or not to accept or reject that risk is based, at least in part, on evaluating the consequences of a mistake. While Hempel (1965) and Rudner (1953) highlighted the moment of inductive risk when scientists decide on evidential sufficiency, other philosophers of science have pointed to inductive risk at other points within scientific work, including in choosing methodology, characterizing evidence, and interpreting data (Douglas, 2009). Although whether or not all of these should be classified as inductive risk is still open to debate (Biddle, 2016), they nonetheless highlight moments where non-epistemic values are enrolled in the scientific process.

3.3 Pragmatic Encroachment

While the argument from inductive risk helps explain how non-epistemic values play a role in the "internal" workings of science, pragmatic encroachment clarifies how practical matters encroach on epistemic ones (Fantl and McGrath, 2002). Although emerging from a different philosophical tradition, pragmatic encroachment also describes the levels of certainty necessary to attain truth as an epistemic community comes to decide not only what is valuable to study but also what will be asserted as true.

Pragmatist philosophy explains how reasons become sufficient for action, even in the face of uncertainty (Bromley, 2006). In this framework of reasoning, a belief becomes a truth when the belief is "no longer reasonable to doubt" (Bromley, 2008: 8; Peirce, 1877). This means that there can only be sufficient reason to act, but never absolute certainty. By identifying the impossibility of certainty, pragmatism address how decision-making can occur within an uncertain environment by focusing on beliefs instead of objective truths. Pragmatism also recognizes that what is considered reasonable in terms of both belief and action are contingent upon values and culture, and coming to consensus on what will be considered a "valuable belief," or a belief upon which we are willing to act, is a shared activity (Bromley, 2008). Pragmatic encroachment further explains how the evidential sufficiency required to view a belief as true necessarily includes some practical considerations, because evidential sufficiency is contingent on the importance of a particular goal (Fantl and McGrath, 2002). In other words, as the importance of a particular decision increases, so too does the sufficiency of evidence required prior to acting. Conceptually, pragmatic encroachment helps explain the disconnect between the ESA's values and NOAA Fisheries' efforts by highlighting how different evidential standards are applied to different scenarios, depending on the perceived societal values attached to various outcomes. Because of the societal value placed on hydropower, for example, a BiOp or an adaptive management plan might not even consider certain possibilities. This is yet another way that value decisions can become enrolled in the scientific process itself.

4.0 Adaptive Management and Risk

The arguments from inductive risk and pragmatic encroachment offer an explanation for how it is that non-epistemic values must play a role within science and in the use of science, particularly at the moment of inference where uncertainty and risks are weighed. Inductive risk focuses on the practice of science, while pragmatic encroachment considers how policy makers and others use scientific information to inform action. These philosophical frameworks demonstrate how decisions about the costs of being wrong play an important role in managing uncertainty in the adaptive management cycle. The issue of "time," or how long to wait before drawing an inference, can have high social and non-epistemic costs, especially when dealing with an applied problem as in the case of the ESA. In situations where there is a high level of risk in *not* drawing inferences in a timely way—such as the potential extinction of a species—the speed of decision-making can be critical, and inferences must be often drawn in an expedited manner (Cranor, 1993).

Although there are many sources of uncertainty in science, the need to make timely decisions and act—to decide on acceptable levels of inductive risk—is one reason for the widespread adoption of adaptive management. In other words, adaptive management is fundamentally about dealing with inductive risk. While uncertainty is often conceptualized as a problem that can be solved through increasing facts and doing "more and better" science, the BiOps demonstrate that this is not necessarily the case. Models and combinations of models have not provided a solution, and the proliferation of models on fish passage and ecological effects of the dams within the BiOps have not ended the controversies over what level of uncertainty—and by extension risk—is tolerable (Doremus, 1997). This is because deciding on level of risk is a value choice, which to date have been embedded and thus somewhat hidden in agency science. Unless the non-epistemic value choices are made clear, NOAA Fisheries and the BiOps will continue to struggle in the courts. If adaptive management is to manage risk effectively in a manner that is consistent with the ESA's requirements, these value choices must be clarified throughout the adaptive management process.

4.1 The Best Available Science

Recognizing these values helps explain the disconnection between what the "best available science" is expected to provide and what it can actually achieve in terms of assisting agency decision-making. Because all scientific decisions involve some element of inductive risk, and the consequences of this risk are measured by the values of society, deciding what the "best" available science is involves weighing these risks in terms of specific aims and goals (Powers, 2017). The consequences of a scientific conclusion being wrong occur outside of science itself, and the assessment of those consequences requires the use of non-epistemic values that should be recognized in order to make a decision about what is "best." In this view, the "best available science" should recognize the inherent inductive risk and how it relates to the non-epistemic consequences related to that risk.

Locating further non-epistemic values in science can also help demonstrate that the "best available science" is influenced by choices about what to study and what methods to use to study it. These choices can be taken by reflecting on appropriate roles of values in science (Douglas, 2000; 2009), and can take place throughout the scientific process including in modeling (Intenmann, 2015) and in assessing the validity of those models (Elliott and McKaughn, 2014). Pragmatist philosophy also demonstrates that what constitutes "truth" can vary between individuals who place differing levels of importance on a particular action, even if they possess the same epistemic knowledge. Put more bluntly, someone who cares little about salmon—or who values hydropower—might require less in the way of assurances that an action would not harm salmon than someone who cares a lot about the species.

Locating these non-epistemic values elucidates the struggles between NOAA Fisheries and the courts tasked with assessing the validity of their science. The court recognizes the societal-importance of salmon conservation and the legal mandate to ensure recovery, and thus desires a high level of certainty before acting in a way that might affect salmon. In fact, certainty and predictability are two of the most fundamental values in legal culture, and in large part justify the very existence of legal regimes. Law is primarily about clearly identifying and securing the rights, privileges, powers, and immunities that form the institutional structure of any social system. Whether it be establishing real property boundaries or the rights and duties in a contract, or securing the rights of an individual, the law seeks always to avoid uncertainty. The BiOp courts, raised in this cultural tradition, struggle mightily with an approach that appears to be nothing but a promise to "figure it all out in the future." The idea is contrary to the values of the legal tradition. The court's decisions have shown that turning to adaptive management has not been satisfactory in this regard. To the extent legal actors must accept uncertainty, they must look outside of the legal tradition to determine how much or what types of uncertainty to accept.

The values of science are just the opposite. At its most fundamental, science recognizes and accepts uncertainty. The scientific method itself makes its truth claims not by proving theoretical propositions, but by failing to disprove them. Fundamental questions remain unanswered, scientific conclusions are framed as likelihoods with margins of error, some scientific disciplines (e.g., nonlinear dynamics) are themselves about understanding uncertainty, and Schrödinger's cat is simultaneously both alive and dead. Given this epistemic culture, when science is converted to action, scientists and managers must look outward—to a non-epistemic set of values—to find a structure of certainty. By their nature, these values are thus not integral to the science itself, nor necessarily obvious to the user or consumer of the scientific tools or conclusions, including the courts.

NOAA Fisheries, as a government agency, policy maker, and consumer of science is thus caught in between the values of the law, of science, and of the broader social structure. As part of that larger social structure, it recognizes an additional set of values: the need to preserve the status quo, to provide for shipping opportunities or hydropower, or to implement the ESA without causing "needless economic dislocation."[6] Hence, what is of concern to NOAA Fisheries

[6] The U.S. Supreme Court has characterized the need to "avoid needless economic dislocation" as one of the purposes of the "best scientific and commercial data available" standard in Section 7 of the ESA. Bennett v. Spear, 520 U.S. 154, 176–77 (1997).

includes hatchery science, transport of fish by barge, fish passage, the effects of spilling water over dams, and similar mitigation strategies that avoid dam removal. The courts and the agency—both attempting to understand and use science, but approaching the science from different cultural traditions, and potentially misunderstanding the cultural tradition of science itself—are thus thinking of salmon management differently, have different goals, and require different kinds of scientific evidence and levels of certainty before acting. Each is using a different set of both epistemic and non-epistemic values to address uncertainty, without explicitly recognizing the nature or structure of those values. Conceptualizing non-epistemic values therefore highlights the disjuncture between the ESA's values and NOAA Fisheries' efforts by demonstrating how only certain possibilities are even considered in a BiOp or an adaptive management plan.

Knowledge is situationally dependent on what is socially interesting, relevant, desirable, and practical (Fantl and McGrath, 2009). For example, while the BiOps analyze the effects of dam operations, they do not propose dam removal and restoration to a free-flowing river as a mitigation option, at least partly because of the agencies' different values. The different values in turn affect adaptive management planning because uncertainty in terms of what will be done becomes confused with uncertainty about what is known. Because the set of values the agency uses to address uncertainty is never explicitly stated, nor the reason for the use of those values, the court cannot determine if (or more accurately, cannot conclude that) the agency is using the "best available science" to ensure no jeopardy to listed salmonids. Value decisions about what is practical materially and politically thus masquerade as science—i.e., what is *easiest* to do becomes what is *best* to do— therefore closing off possibilities for management and inhibiting the *adaptability* of adaptive management. Agencies and courts often conflict over value judgments (Doremus and Tarlock, 2005). Yet even if their values are aligned, when adaptive management is incorporated into a mitigation plan what is deemed uncertain must be made clear—specifically whether the uncertainty is fundamental to the science itself, or whether it is uncertainly about what the agency thinks it can or should do. Scientific uncertainty is an integral part of the "best available science;" political uncertainty is not. Only when both scientists and the agencies express all of their values, and their sources, can all possibilities, avenues for action, and uncertainties—no matter how understudied, or seemingly impractical—be considered to prevent the extinction of a species. When all values are recognized, the courts can identify when uncertainty, even as addressed in an adaptive management plan, is part of the best available science itself.

4.2 Adaptive Management Without the Value-Free Ideal

If we accept that uncertainty is fundamental, we can better see how it is often used to put off difficult decisions that are political in nature, as policy advocates and scientists pick and choose which uncertainties to emphasize and how much risk to tolerate (Herrick and Sarewitz, 2000). Yet if we accept that the value-free ideal of science is impossible (Douglas, 2000), we can become aware of the role of values in science, and how uncertainty is dealt with through adaptive management. As the example of the BiOps illustrates, being unclear about these values has led to the *politicization*—and de-legitimization— of science (Brown, 2015). The blame is often placed on adaptive management. Clarity and openness about values is what Elliot and Resnick (2014) refer to as "the best path to promoting good science and policy" (p 647). Acknowledging that uncertainty can only be managed and not eliminated (Funtowicz and Ravetz, 1990), and recognizing where consensus does not exist, would therefore strengthen the legitimacy of science, not threaten its objectivity (Elliot and Resnik, 2014).

These conceptual moves are necessary in order to make adaptive management work—and to satisfy the ESA. However, recognizing values in science does not mean deferring decisions about values from "within" science "out" to policy-makers or the courts (e.g. Betz, 2013; Jeffrey, 1956). The argument from inductive risk demonstrates that scientists must also make non-epistemic value decisions because it is philosophically (Douglas, 2009) and technically impossible (Havstad and Brown 2017) to avoid it. Some recent models for dealing with values in science include Pielke's (2007) "honest broker of policy alternatives" and Edenhofer and Kowarch's (2015) "pragmatic enlightened model (PEM)," in which "policy pathways" that account for different values are presented to policy-makers. But these models have also been shown to fail to incorporate inductive risk and by extension the impact of non-epistemic values in science (Havstad and Brown, 2017).

If the mandate to use the "best available science" is truly followed, all possibilities must be considered in a management plan, yet this is not practically feasible, as demonstrated through critiques of the PEM (Havstad and Brown, 2017). There is a danger that adaptive management will follow the path of the PEM, deferring decisions about values to policy-makers, and never explicitly acknowledging the value decisions that scientists must make. Recognizing non-epistemic values in adaptive management will avoid this mistake.

5.0 Conclusion

If we recognize that non-epistemic values are a part of the internal working of science, what are the implications for adaptive management, and the case of the BiOps specifically? Adaptive management is unique because of the way that it openly deals with uncertainties through deliberation, and because it highlights the practical, applied implications of non-epistemic choices in science through its iterative nature. Through its iterative structure, adaptive management incorporates stakeholder engagement between scientists and policymakers, and each of these moments is an opportunity to address the values that underlie both science and policy. These unique qualities are strengths from which to draw, and can help to address the problems that non-epistemic values present for science-based policy decisions like those described here.

The practical implications of inductive risk and other non-epistemic values and how to deal with them are just beginning to be explored by science studies scholars. There are still major questions that need to be addressed relating to the nature of inductive risks, how and when they can be evaded, and how to address them responsibly at the science-policy interface (Elliott and Richards, 2017). Recognizing non-epistemic values in science provides several openings where more intentional management goals and implications can be developed. We propose three ways that they should considered within adaptive management through: 1) describing non-epistemic values, including standards of evidence transparently, 2) articulating aims and goals openly, and 3) acknowledging the role of institutions in setting standards of risk.

5.1 Making Standards of Evidence Transparent

Inductive risk and pragmatic encroachment demonstrate that deciding on standards of evidence require non-epistemic values. Even if courts are ultimately deciding on what will count as "best available science," we have shown how non-epistemic values are employed at decision-points within scientific practice. Standards of evidence should be articulated clearly at all stages of both science and decision-making. This will help clarify what is meant by "best available science." According to the argument from inductive risk uncertainties related to how much risk a society is willing to take are also embedded within science. Determining the acceptable level of risk is due, in part, to the consequences of that risk. Adaptive management plans should recognize and articulate the consequences of making a mistake, by addressing where both implementation and effectiveness of mitigation measures are uncertain due to political, scientific, or other uncertainty. Conceptualizing non-epistemic values in science increases the legitimacy of adaptive management not only in the legal controversy over science in the Columbia River Basin, but in any circumstance where science directly leads to policy outcomes.

5.2 Articulating Aims and Goals

Setting aims and goals for the role of values in science, especially when science is enrolled in legal decisions would make epistemic and societal actions more open (Elliott and Richards, 2017). If the aims of inquiry are stated up front, we are more likely to have the “best available science” to meet those goals. Pragmatism demonstrates that when initially assessing a problem, some possibilities can get foreclosed—what is *easiest* to do can become what is *best* to do as only certain possibilities are considered. While the problem will always be socially defined, explicitly articulating non-epistemic values allows the problem to be reframed to include a more complete range of management possibilities and potential futures. Similarly, when assessing current knowledge, an understanding of non-epistemic values demonstrates that the “best available science” does not necessarily consider that some knowledge or data may be unavailable. Identifying what knowledge is needed is critical at this stage, and if uncertainties exist they should be clearly articulated in relation to the aims and goals. For example, explicitly stating what the desired environmental state will be (ie. recovered salmon with or without dams or other uses of the river) and allowing the goal itself to be assessed and critiqued openly, along with the science that might achieve it.

5.3 The Role of Institutions

This article demonstrates that non-epistemic values clearly play a role in the dynamics of legal institutions. Elliott and Richards (2017) ask whether or not there are ways to "codify responses to inductive risk in institutions" (p. 271), but wonder whether this might hide these judgments or hinder scientific responsibility. To be sure, the court's role in setting standards of evidence is one place where they can begin to recognize inductive risk (Cranor, 2008). When science finally reaches the courts, it is already "saturated with value judgments" and trade-offs (Miller, 2014). This is not a problem, but a central feature of both scientific and democratic processes. This process is illustrated through an exploration of the role of non-epistemic values in science, inductive risk and pragmatic encroachment, and the ways in which these can be addressed by courts and other institutions. How best to do this is a question for future research, and will involve considering the fundamental adaptability of legal institutions themselves (Cosens et al., 2017). Even if adaptive management is implemented within the framework of the ESA, managing to balance flexibility and experimentation on the one hand and the mandate to recover salmon at whatever the cost on the other will require identifying ways to facilitate institutional adaptation, while preserving legitimacy (Cosens et al., 2017). However, there are still steps that can be taken to acknowledge institutions' role in setting standards for inductive risk (Elliot and Richards, 2017).

The need to make natural resource management decisions in a timely manner is becoming even more crucial as climate change increases the speed at which damage to species, populations, and ecosystems can occur. As this happens, understanding and recognizing values in science becomes even more important, so that decisions can be deliberated openly and quickly while at the same time increasing the legitimacy of science. For adaptive management to function, values must be made clear before they derail the adaptive management cycle. This will not be accomplished by drawing a distinction between science as a realm without values and the court as the place of values, instead it will require a reexamination of the nature of science, adaptive management, and decision-making on behalf of both scientists and the public so that the "best available science" can be clearly deliberated.

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