Science, Policy, and Data-Driven Decisions in a Data Vacuum

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Environmental regulation invariably requires making decisions in the face of scientific uncertainty. However, making decisions in the near-absence of evidence—essentially, the most extreme uncertainty—is a special case because it most plainly exposes the defaults and preferences of those making the decisions, and because it may inspire creative ways of reducing the probability of error. Here, we relate the case of an Endangered Species Act listing of several rockfish species in Puget Sound, Washington, which illustrates a set of decisions the National Marine Fisheries Service made in the absence of critical information about those populations. Subsequent scientific effort and technological advances have been powerful tests of the listing decision, and have suggested different outcomes for each of the three species under evaluation. We discuss this case in the context of agency discretion and internal incentives to make or defer decisions. We then highlight the roles of technological change and institutional learning as they intersect with these incentives, and suggest structural means of enabling this kind of effective data use by administrative agencies more generally.

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INTRODUCTION

A 2007 petition to the National Marine Fisheries Service (NMFS) suggested that yelloweye rockfish had become vanishingly rare within Puget Sound,[1] even though they were routinely caught on the outer coast of Washington, just a short distance away. A key question was whether fish from these two places were different, such that one might merit protection under the Endangered Species Act (ESA or the Act)[2] while the other might remain

1. Notice of Finding on a Petition to List Five Rockfish Species in Puget Sound (Washington) as Endangered or Threatened Species Under the Endangered Species Act, 73 Fed. Reg. 14,195, 14,195 (Mar. 17, 2008) (to be codified at 50 C.F.R. pts. 223 & 224) (describing October 2007 petition). The October 2007 petition was a request to reconsider an earlier petition from the same party, Sam Wright of Olympia, Washington, and provided supplemental data. *See* Threatened Status for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye and Canary Rockfish and Endangered Status for the Puget Sound/Georgia Basin Distinct Population Segment of Bocaccio Rockfish, 75 Fed. Reg. 22,276, 22,277 (Apr. 28, 2010) (to be codified at 50 C.F.R. pts. 223 & 224). We focus our discussion on the question of whether the Puget Sound fishes were populations discrete from the outer coast, but also touch upon the question of whether the petitioned species—as opposed to rockfishes generally—were declining in abundance. We take up the latter question in Part V.

2. 73 Fed. Reg. at 14,195.

commercially exploitable.[3] If the Puget Sound and outer coast fish belonged to a single population with a broad geographic range, however, the species would not have deserved special protection. The petition raised these same legal questions—*were the petitioned Puget Sound species distinct population segments (DPSs) under the ESA, and if so, were they indeed declining in abundance*?—for four other rockfish species in addition to the yelloweye: bocaccio, canary rockfish, greenstriped rockfish, and redstripe rockfish.[4]

NMFS had almost no data with which to evaluate the precise question at hand; no one had ever measured genetic or demographic differences for these species between the putatively distinct coastal and Sound populations. Given that the burden was on the petitioner to show that the proposed listing might be warranted,[5] and given that direct evidence of the populations' distinctness did not exist, the agency could have determined that the petition did not contain information sufficient to move forward with a listing analysis.[6] Such a determination would have stopped the petition in its tracks, and would have been consistent with the behavior of NMFS and the Fish and Wildlife Service (FWS) towards many such data-poor petitions in the past.[7] Indeed, the scarce resources with which these agencies manage the more than 2500 listed species[8]—and respond to the many petitions to list additional species—nearly demand such parsimony on the part of the agencies.[9]

Instead, NMFS took up the petition and spent the next year doing creative, in-depth analysis of sparse data. The agency ultimately listed three of the

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3. Outer coast yelloweye rockfish are overfished under the Magnuson-Stevens Act (16 U.S.C. §§ 1801–1891d), and so are not exploited at present, but could again be fished after the stock rebuilds. *Fishery Management Plan and Amendments: FMP: Amendment 16-4,* PAC. FISHERY MGMT. COUNCIL, http://www.pcouncil.org/groundfish/fishery-management-plan/fmp-amendment-16-4/ (last updated May 7, 2010) (describing rebuilding plan for yelloweye and other depleted/overfished species); *see Groundfish: Fishery Management Plan and Amendments*, PAC. FISHERY MGMT. COUNCIL, http://www.pcouncil.org/groundfish/fishery-management-plan/ (last updated Dec. 29, 2016).

4. *See generally* JONATHAN S. DRAKE ET AL., NOAA TECHNICAL MEMORANDUM, STATUS REVIEW OF FIVE ROCKFISH SPECIES IN PUGET SOUND, WASHINGTON, (2010). It is not obvious why greenstriped and redstripe rockfishes have names of different forms, but such is life in biological nomenclature.

5. "[T]he Secretary shall make a finding as to whether the *petition presents* substantial scientific or commercial information indicating that the petitioned action may be warranted. If such a petition is found to present such information, the Secretary shall promptly commence a review of the status of the species concerned." 16 U.S.C. § 1533(b)(3)(A) (2012) (emphasis added).

6. That is, a "not warranted" ninety-day finding. § 1533(b)(3)(B).

7. For example, NMFS had previously denied rockfish listing petitions (the agency found them not to be warranted) from the same petitioner, including one earlier in the same year (2007), citing a lack of data. *See* 73 Fed. Reg. at 14,195. *See also infra* Part III.

8. The FWS list of endangered species contained 1438 animals and 901 plants as of January 2017. *See Threatened & Endangered Species*, ENVTL. CONSERVATION ONLINE SYS., U.S. FISH & WILDLIFE SERV., http://ecos.fws.gov/ (last visited Jan. 13, 2017).

9. One might argue that the agencies lack the discretion to pursue petitions that do not meet the relevant evidentiary burden. Nevertheless, given that agencies may list species on their own initiative in the absence of any petition at all, it seems likely that agencies have the authority to engage in the kind of analysis NMFS did in the rockfish example, following up on a petition that lacked data directly on point. *See* § 1533(b)(1). *See* discussion *infra* Part III.

petitioned species in 2010.[10] NMFS then voluntarily generated its own data and tested its listing determinations against the new datasets using cutting-edge genetic techniques. Thus, instead of acting as agencies are often expected to—by minimizing litigation risk, minimizing effort at the level required by law, and acting to preserve their own discretion[11]—NMFS engaged in a rather more vigorous attempt to develop scientific information to better inform the policy process.

In this Article, we relate the story of how NMFS decided to list these three Puget Sound fish populations under the ESA. We use this listing decision as an example of many such decisions that administrative agencies make in which critical information is either very scarce or entirely absent. Such decisions provide a window into the baseline assumptions that policy actors make about the world.[12] In the rockfish example, can one assume the populations are distinct until proved otherwise, on the basis of reasonable inferences? Or must the agency have data on point before acting, in order to meet its evidentiary burdens?[13] Here, timely analytical and technological advances played important roles both in helping NMFS meet its legal burden for listing and in reinforcing NMFS scientists' incentives to do so.

The rockfish decision also provides a special case of adaptive management in practice, although the decision itself was not couched in such terms and there is no evidence the NMFS scientists were consciously engaged in an adaptive-management process. Actual adaptive management is hypothesis testing in action.[14] Here, NMFS made a listing decision based upon the best (albeit thin)

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10. The three listed species were yelloweye rockfish (*Sebastes ruberrimus*; threatened), bocaccio rockfish (*S. paucispinis*; endangered), and canary rockfish (*S. pinniger*; threatened). Threatened Status for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye and Canary Rockfish and Endangered Status for the Puget Sound/Georgia Basin Distinct Population Segment of Bocaccio Rockfish, 75 Fed. Reg. 22,276, 22,276 (Apr. 28, 2010) (to be codified at 50 C.F.R. pts. 223 & 224).

11. This thumbnail sketch of agency behavior is an extension of more fundamental observations about principal-agent interactions, in which the agent—here, a federal agency—is a rational actor seeking to discharge its duty while minimizing its costs. A large literature exists on principal-agent and other theories of administrative behavior. For relevant reviews, see generally Steven P. Croley, *Theories of Regulation: Incorporating the Administrative Process*, 98 COLUM. L. REV. 1 (1998); Brigham Daniels, *Agency as Principal*, 48 GA. L. REV. 335 (2014) (challenging traditional principal-agent models of agency behavior); McNollgast, *Political Control of the Bureaucracy*, *in* THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND LAW 50 (Peter Newman ed., 1999). Note also that our brief characterization of agency behavior assumes that the agency complies with its congressional mandate, although degrees of agency noncompliance happen routinely. *See, e.g.,* Miranda Yaver, When Do Agencies Have Agency? The Limits of Compliance in the EPA (Oct. 29, 2014) (Ph.D. dissertation, Columbia University) at 1, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2467611.

12. These are identical to the scientific-philosophical concept of a null hypothesis.

13. On which, in the context of torts, see generally Steve Gold, Note, *Causation in Toxic Torts: Burdens of Proof, Standards of Persuasion, and Statistical Evidence*, 96 YALE L.J. 376 (1986). For further discussion of the importance of the null hypothesis in ESA cases, see Berry J. Brosi & Eric G. Biber, *Statistical Inference, Type II Error, and Decision Making under the US Endangered Species Act*, 7 FRONTIERS IN ECOLOGY & THE ENV'T 487 (2008).

14. *See* KAI N. LEE, COMPASS AND GYROSCOPE: INTEGRATING SCIENCE AND POLITICS FOR THE ENVIRONMENT 53 (1993) ("An adaptive policy is one that is designed from the outset to test clearly formulated hypotheses about the behavior of an ecosystem being changed by human use.").

evidence available, and in the succeeding years tested the validity of that decision by collecting additional data and improving its analytical approaches.[15] The ESA and its implementing regulations provide the criteria by which to judge the appropriateness of the listing decision in light of new evidence; consequently, in January 2017, NMFS removed the canary rockfish[16] (one of the three species listed in 2010) from the federal list of threatened and endangered species.

In Part I of this Article, we provide a brief background on the ESA, rockfish, and Puget Sound. Part II relates the facts of the listing decision and subsequent analyses that NMFS has conducted in collaboration with scientists outside of the agency. In Part III, we assess the rockfish listing and other ESA listings in the context of the uncertainty under which the agencies necessarily make such decisions, and in Part IV, we show how the agency's actions in the rockfish case reduced the risk of error, given the scarce data available. Part V then asks why the agency acted as it did in this case, highlighting the roles of institutional design and technological and analytical advances in influencing agency incentives. Part VI relates these observations to the process of community-wide learning under conditions of significant uncertainty. Finally, we conclude by suggesting that the rockfish case illustrates one kind of science-driven policy structure that might be a model for agency action more broadly.[17]

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15. One might also see this as an example of Bayesian decision making, in which an updated decision arises from new evidence in light of prior expectations (based upon earlier work or background information) or prior data. We see this kind of decision-making process as equivalent to adaptive management as we use the term here. *See* Aaron M. Ellison, *An Introduction to Bayesian Inference for Ecological Research and Environmental Decision-Making*, 6 ECOLOGICAL APPLICATIONS 1036, 1043 (1996) ("Adaptive management is precisely analogous to an iterative Bayesian learning and decision process."). We note that the Bayesian framing is especially appropriate where, as in the example of the rockfish, the data available on which to base a critical decision were sparse. Bayesian inference makes efficient use of sparse data by treating any available information as a modifiable prior inference. "[E]nvironmental decisions rarely are made in light of complete and certain data, so decisions should be made in ways that reflect the uncertainty and that can be modified when new data become available." *Id*.

16. Removal of the Puget Sound/Georgia Basin Distinct Population Segment of Canary Rockfish From the Federal List of Threatened and Endangered Species and Removal of Designated Critical Habitat, and Update and Amendment to the Listing Descriptions for the Yelloweye Rockfish DPS and Bocaccio DPS, 82 Fed. Reg. 7711, 7711 (Jan. 23, 2017) (to be codified at 50 C.F.R. pts. 223 & 224).

17. We also contrast the rockfish listing process with the outcomes likely to occur under FWS's recently published ESA prioritization scheme, in which species about which less is known receive lower listing priority from the agency. Methodology for Prioritizing Status Reviews and Accompanying 12-Month Findings on Petitions for Listing Under the Endangered Species Act, 81 Fed. Reg. 49,248, 49,250 (July 27, 2016) ("Actions for a species where limited information is available regarding its threats or status will be given fifth highest [i.e., lowest] priority . . . . [W]e need to make listing decisions based on the best available scientific and commercial data. Because the best available data for species in this bin may be very limited even if the Service conducts further research, we will prioritize work on species for which we have more and better data already available."). There is a clear tension in this new set of priorities: on the one hand, the lack of information about a species does not mean that species is not endangered, "the concept of not knowing enough about a species is not a basis for a not-warranted finding", 81 Fed. Reg. at 49,253; but, on the other hand, "[i]f the best available scientific and commercial information is extremely limited . . . there is a good chance [FWS] would find at the 90-day finding stage that the petition does not present substantial information." *Id*.

I. BACKGROUND: ESA, ROCKFISH, AND PUGET SOUND

A. Salient Rules of the ESA

The ESA is one of the most written-about environmental laws in the United States, and we will not revisit all of its relevant provisions here; however, we highlight an important detail of the ESA listing process that animates the case of Puget Sound rockfishes: the authority of NMFS and FWS to list a portion of a vertebrate species as threatened or endangered, even if the species in its entirety does not merit ESA protection.

The agencies may list species, subspecies, and DPSs for protection under the Act.[18] This last category applies to vertebrate animals alone,[19] and is relevant where only a "discrete" and "significant" population of the species is imperiled.[20] Once listed, any of the three entities—species, subspecies, or DPS—is legally equivalent under the ESA and is (confusingly) referred to as a listed "species."[21]

To illustrate, suppose the American crow (*Corvus brachyrhynchos*, which can be so common as to be an annoyance)[22] had a small population in the foothills of the Cascade Mountain range, and that this population were geographically isolated from all other crows. Suppose further that the foothill population had a slightly different breeding season than other crows, perhaps as a consequence of their isolation, and that the foothill crows were specifically targeted by hunters due to the crows' unusual ability to identify and steal hunters' lunches from their packs.

Given such a scenario, the foothill crows might plausibly be listed as a DPS under the Act, despite the fact that crows at large are anything but endangered.[23] Here, the foothill population is discrete, being "markedly separated from other populations of the same taxon as a consequence of

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18. *See* 16 U.S.C. § 1532(16) (2012).

19. *Id*.

20. *See* Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722, 4722 (Feb. 7, 1996) (notice of policy).

21. Note 61 Fed. Reg. 4722 quotes the language of an earlier Senate report, relating that Congress had instructed the agencies to use the DPS provision "sparingly and only when the biological evidence indicates that such action is warranted.*" See id.* The Policy itself, and the agencies' response to a public comment on the Policy each echo the understanding that designation of a DPS was to be the exception, rather than the rule, in ESA listings. *Id*. at 4725 (noting Congressional guidance "that the authority to list DPS's be used 'sparingly'"); *id*. at 4724 ("The Services believe that application of the policy framework announced in this document will lead to consistent and sparing exercise of the authority to address DPS's, in accord with congressional instruction."). Such language strongly suggests a presumption against the existence of discrete and significant populations in the absence of evidence to the contrary.

22. We use this hypothetical to underscore the idea that even an otherwise-common species can have a threatened or endangered DPS.

23. Coho salmon are a real-world example of this phenomenon. Refer to NOAA's information on the Coho Salmon for an encapsulation of ESA-listed populations (known as "Evolutionarily Significant Units" or "ESUs"), and contrast this with the fact that the same species is a significant and valuable commercial fishery. *Coho Salmon (Oncorhynchus kisutch)*, NOAA FISHERIES, http://www.fisheries.noaa.gov/pr/species/fish/coho-salmon.html (last updated Jan. 5, 2017).

physical, physiological, ecological, or behavioral factors."[24] The population is at least arguably significant to the larger crow species, assuming the foothills are "an ecological setting unusual or unique for the taxon."[25] And if hunting pressure renders the population sufficiently imperiled to meet the definition of "endangered"[26] or "threatened"[27] under the ESA, the foothill crows could become a DPS worthy of the Act's full protection.

The DPS provision has proved useful for agencies where particular populations of a species merit special treatment,[28] or where it is necessary to retain protections for identifiable populations while removing protections for the bulk of a species.[29] Although genetic data are often important in helping the agencies analyze both the discreteness and significance prongs of a DPS evaluation,[30] there is no requirement that genetic data be available before listing a DPS.[31]

B. A Brief Introduction to Rockfishes

Rockfishes[32] (here, referring to fishes in the genus *Sebastes*) are a set of closely related fish species predominant in the North Pacific.[33] Ninety-six species occur in the North Pacific,[34] inhabiting diverse habitats from nearshore

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24. 61 Fed. Reg. at 4725.

25. *Id*.

26. 16 U.S.C. § 1532(6) (2012) ("[I]n danger of extinction throughout all or a significant portion of its range.").

27. § 1532(20) ("[L]ikely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.").

28. For example, the Southern Resident Killer Whale is endangered, while other populations of the same species are not. *See Killer Whale (Orcinus Orca)*, NOAA FISHERIES, http://www.nmfs.noaa.gov/pr/species//mammals/whales/killer-whale.html (last updated Feb. 10, 2016).

29. *See, e.g.*, Identification of 14 Distinct Population Segments of the Humpback Whale (*Megaptera novaeangliae*) and Proposed Revision of Species-Wide Listing, 80 Fed. Reg. 22,304 (Apr. 21, 2015) (to be codified at 50 C.F.R. pts. 223 & 224); Removing the Western Distinct Population Segment of Gray Wolf From the List of Endangered and Threatened Wildlife, 68 Fed. Reg. 15,879 (Apr. 1, 2003) (to be codified at 50 C.F.R. pt. 17).

30. *See* Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722, 4725 (Feb. 7, 1996) (giving genetic data as an example of relevant information for both discreteness and significance prongs).

31. Moreover, absence of evidence showing a genetic pattern is not evidence of its absence; a small amount of genetic exchange among populations might be ecologically insignificant, but homogenize the population genetics of a species. For a discussion of the relevance of genetic data to ESA listing decisions, with examples, see generally Ryan P. Kelly, *The Use of Population Genetics in Endangered Species Act Listing Decisions*, 37 ECOLOGY L.Q. 1107, 1107–1159 (2010).

32. Following the convention of biologists, where we refer to a single species of rockfish, we try to use the singular "rockfish," and where we refer to more than one species, we use the plural "rockfishes." The same rule applies to "fish" and "fishes."

33. For information on Pacific rockfishes, see generally MILTON S. LOVE ET. AL., THE ROCKFISHES OF THE NORTHEAST PACIFIC (2002). This book probably contains more information than any reader of law review articles would hope to have on the topic.

34. K.L. YAMANAKA ET AL., FISHERIES & OCEANS CAN., A REVIEW OF YELLOWEYE ROCKFISH SEBASTES RUBERRIMUS ALONG THE PACIFIC COAST OF CANADA: BIOLOGY, DISTRIBUTION AND ABUNDANCE TRENDS, CANADIAN SCIENCE ADVISORY SECRETARIAT, RESEARCH DOCUMENT 2006/076,

waters to depths of hundreds of meters. And rockfish can have extraordinarily long lives, with many living over 100 years and an individual of at least one species living to be as old as 205 years.[35] Dozens of these species are commercial- and sport-fishing targets, given that they can be of substantial size[36] and deliciousness.

At least three factors make rockfish species vulnerable to potential over-exploitation: (1) their size and quality make them sought-after fishing targets; (2) young rockfish do not mature for several years (eighteen years in the case of yelloweye),[37] slowing population growth relative to earlier-maturing species; and (3) younger adults can be less reproductively successful than older adults (that is, fecundity increases with age),[38] such that fisheries targeting older, larger individuals may disproportionately slow population growth. As a consequence, Puget Sound rockfishes have been in decline for decades.[39]

A final relevant habit of rockfishes is the tendency, within most species,[40] for adults to remain in a fixed geographic position, occupying a small "home range" over many years.[41] In contrast to the image of many Pacific fish species as forming large, mobile schools, adult rockfish can be relatively sedentary for decades[42] (although some species do form schools in the water column).[43] As such, the idea that these species might have isolated populations in water bodies such as Puget Sound is not far-fetched.

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at 1 (2006), http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2006/RES2006_076_e.pdf.

35. *S. Aleuticianus*, ALASKA FISHERIES SCI. CTR., http://www.afsc.noaa.gov/Rockfish-Game/description/rougheye.htm (last visited Jan. 13, 2017).

36. Yelloweye can be nearly one meter long. *See* LOVE ET AL., *supra* note 33, at 57–63.

37. YAMANAKA ET AL., *supra* note 34, at ix.

38. *See generally* Steven A. Berkeley et. al, *Maternal Age as a Determinant of Larval Growth and Survival in a Marine Fish,* Sebastes Melanops, 85 ECOLOGY 1258 (2004).

39. *See generally* WASH. DEP'T OF FISH & WILDLIFE, ENVIRONMENTAL IMPACT STATEMENT FOR THE PUGET SOUND ROCKFISH CONSERVATION PLAN 1 (2011) ("Rockfish in Puget Sound are in trouble. Many, but not all, rockfish species have declined in abundance, some quite severely, over the past two decades."); Gregory D. Williams et. al., *Rockfish in Puget Sound: An Ecological History of Exploitation,* 34 MARINE POLICY 1010 (2010).

40. There are exceptions; for example, *S. flavidus* may travel hundreds of kilometers as juveniles. LOVE ET AL., *supra* note 33, at 178. However, the majority of *Sebastes* species are thought to remain in one place for many years. Anne H. Beaudreau & Emily J. Whitney, *Historical Patterns and Drivers of Spatial Changes in Recreational Fishing Activity in Puget Sound, Washington*, 11(4) PLOS ONE e0152190 (2016) ("rockfishes show strong fidelity to rocky reef habitats and occupy small home ranges, some as small as 10 square meters") (citing LOVE ET AL., *supra* note 33).

41. However, rockfish larvae can persist in the water column for months, and in some species this larval stage is an effective means of dispersal. DRAKE ET AL., *supra* note 4, at 7, 46. The Biological Recovery Team thus had to weigh evidence relevant to the petitioned species, asking whether it was more likely that these species were sufficiently sedentary that they formed discrete populations from the outer coast fish, or instead, whether the two geographies were probably linked by individual adults or larvae that kept the Puget Sound and outer coast locations well connected in a single demographic and genetic population.

42. *See generally* LOVE ET AL., *supra* note 33.

43. Such species include, for example, the widow rockfish. *See id.* at 172.

C. Puget Sound and Biogeography in the Pacific Northwest

Puget Sound is a deep gouge in the landmass of the northwestern United States, a glacier-carved inlet that is the nation's largest estuary after the Chesapeake Bay.[44] The Sound is home to thousands of estuarine and marine species—from iconic species like orca, bald eagle, and salmon, to polychaete worms that only a marine biologist could love.[45] Such abundant wildlife has long provided sustenance, recreation, ceremonial value, and commercial opportunity for the Sound's human population, which now includes about four million people.[46]

A surface map of Washington and British Columbia suggests that Puget Sound and related waterways[47] are merely extensions of the Pacific Ocean, saltwater fingers keeping the Sound tightly linked to the waters of the outer coast. But a bathymetric map makes clear that Puget Sound is largely separate from the Pacific, made up of several discrete basins with only a surface connection to the ocean.[48] The consequence of this geological separation is a set of oceanographic and ecological factors that distinguish the Sound's marine ecosystem from that of the outer Pacific coast. Accordingly, coast-wide species may have Puget Sound populations with only weak demographic linkages to the species at large.

Hence, the biology of rockfishes (slow-growing and threatened with overexploitation) and the biogeographic context of Puget Sound set up the legal questions that NMFS was facing with regard to the petitioned Puget Sound rockfishes.

II. THE ROCKFISH LISTING DECISION AND ITS REASSESSMENT

In response to the 2007 citizen petition to list the five abovementioned Puget Sound rockfish species as DPSs,[49] NMFS found that listing "may be

44. *See Puget Sound*, EPA, https://www.epa.gov/puget-sound (last visited Jan. 13, 2017).

45. EUGENE N. KOZLOFF, MARINE INVERTEBRATES OF THE PACIFIC NORTHWEST 109 (1996) ("The polychaete fauna of the Pacific Northwest is extremely rich.").

46. PUGET SOUND TRENDS, POPULATION OF CITIES AND TOWNS 1 (2015), http://www.psrc.org/assets/2782/trend-d3.pdf.

47. These waterways include the Hood Canal, the Strait of Juan de Fuca, and the Strait of Georgia. Together with Puget Sound, these waters are known as the Salish Sea. WASH. STATE LEGISLATURE, APPENDIX—DETERMINATION OF GEOGRAPHIC NAMES, WASH. ADMIN. CODE tit. 237, ch. 237–990 (2016).

48. *See* DRAKE ET AL., *supra* note 4, at 18.

49. The petitioner was Sam Wright of Olympia, WA, who had earlier petitioned NMFS to list the DPSs, but had been denied for lack of information sufficient to show listing may be warranted. Petition to List Five Rockfish Species in Puget Sound (Washington) as Endangered or Threatened Species under the Endangered Species Act, 72 Fed. Reg. 56,986, 56,986 (Oct. 5, 2007) (notice of finding). Wright subsequently provided additional information, leading to the ninety-day finding that triggered the Biological Review Team (BRT). Notice of Finding on a Petition to List Five Rockfish Species in Puget Sound (Washington) as Endangered or Threatened Species Under the Endangered Species Act, 73 Fed. Reg. 14,195, 14,198 (Mar. 17, 2008) (to be codified at 50 C.F.R. pts. 223 & 224).

warranted,"[50] and accordingly formed a Biological Review Team (BRT or Team).[51] In particular, for each of the five named species, the Team was to (1) determine whether any Puget Sound population met the discreteness and significance prongs of the DPS analysis,[52] and (2) evaluate the extinction risk for each DPS, considering the relevant statutory factors.[53] Below, we focus on the DPS question—the discreteness and significance of Puget Sound rockfish populations—because it is most relevant to the larger discussion of making decisions with scarce information.

A. Genetics

The Team assembled rockfish data from academic publications, commercial and recreational fisheries catch records, and nonprofit and government surveys.[54] It also reviewed historical references[55] and a host of ecological information ranging from sediment characteristics to urban development in the different parts of Puget Sound.[56] Inferences about genetic connectivity among fish populations were particularly relevant, with demographic trends and physical oceanographic evidence providing useful context. Although the agency is not required to have genetic data in order to define a DPS, genetics underpin many DPS listing decisions, in part because

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50. 73 Fed. Reg. at 14,196 (reconsidering previous petition in light of information on the overall abundance of rockfishes over time in Puget Sound, and regulatory history in the region, and finding that listing may be warranted). This successful petition showed the overall decline in rockfish abundance strongly enough to meet the "may be warranted" threshold, and the subsequent twelve-month analysis focused on the key questions of (1) whether the petitioned species in Puget Sound were discrete from those on the outer coast, and (2) whether the petitioned species were declining as fast as the Puget Sound rockfishes as a group. *Id.*

51. "The BRT for Puget Sound rockfish consisted of Ewann Berntson, Jason Cope, Jonathan Drake (co-chair), Rick Gustafson, Elizabeth Holmes, Phillip Levin (co-chair), Nick Tolimieri, Robin Waples, Northwest Fisheries Science Center; and Susan Sogard, Southwest Fisheries Science Center." DRAKE ET AL., *supra* note 4, at n.1.

52. We reviewed the outlines of these analytical prongs. *See supra* Part 1.

53.

> [T]he [Team] was asked to consider whether the petitioned species meet the criteria for being considered a DPS as defined by the [Joint DPS policy]. If a DPS or DPSs were identified for any of the species in Puget Sound, the [Team] was requested to evaluate the level of extinction risk faced by each DPS throughout its range, assessed as either 'high risk,' 'moderate risk,' or neither, where high and moderate risk were defined with respect to specific reference levels of extinction risk . . . . Finally, the [Team] was requested to document the consideration of threats to the species according to the statutory listing factors: the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; and other natural or man-made factors affecting its continued existence.

DRAKE ET AL., *supra* note 4, at 1. (emphasis added and internal citations omitted). Note that one of the authors of the present Article, Phil Levin, co-chaired the rockfish Team.

54. *See id*. at 60–72.

55. *Id*. at 73.

56. *See, e.g.*, *id*. at 24–27.

such data may simultaneously address the discreteness and significance prongs of the Joint DPS Policy.[57]

At the time of the Team's deliberation, no study had ever spoken to the question of connectivity between Puget Sound and outer coast populations for any of the five petitioned species,[58] and "essentially no genetic data were available that included samples of the petitioned species from Puget Sound."[59] That is, the Team had no data directly on point, and therefore made inferences from (1) genetic data from the petitioned species, but collected from populations elsewhere, and (2) data from analogous species (those other than the petitioned species) for which data were available comparing Puget Sound with outer coast populations.[60]

As to the petitioned species, even data for non-Puget Sound populations were thin. Only three of the five species had any modern genetic data available at all. One species—yelloweye—offered direct evidence of a split between coastal ("outside") populations and those "inside" waters protected by the Queen Charlotte Islands and Vancouver Island in Canadian waters, just north of Puget Sound.[61] The other data on the petitioned species were equivocal, but in the Team's view the weight of existing evidence tended to support the idea that rockfish populations were more likely to be fragmented rather than to be highly connected.[62]

The Team fared better at finding relevant data from closely analogous species, concluding "that the biology and ecology of the petitioned species were sufficiently similar to species that have been subject to genetic analysis and that did include samples from Puget Sound that patterns of variation from these 'surrogate species' should be considered when evaluating potential DPSs for the less-studied petitioned species."[63] Hence, the Team reviewed three other rockfish species—brown, quillback, and copper rockfish—that had previously

57. *See generally* Kelly, *supra* note 31, for a larger discussion of genetics and listing decisions.

58. DRAKE ET AL., *supra* note 4, at 37–40.

59. *Id*. at 40.

60. Interview with Mike J. Ford, Dir. of the Conservation Biology Program, Nw. Fisheries Sci. Ctr. (Jan 25, 2016).

61. *See* DRAKE ET AL., *supra* note 4, at 38–39.

62. Two bocaccio datasets focused primarily on fish from the open coasts of Oregon and California, finding no strong geographic-genetic structuring among sampled populations. *See id.* at 37–38; *see generally* Andrew P. Matala et al., *Microsatellite Variation Indicates Population Genetic Structure of Bocaccio*, 24 N. AM. J. FISHERIES MGMT. 1189 (2004). Subsequent analysis also found a lack of strong structure. *See* JOHN C. FIELD ET AL., PACIFIC FISHERY MGMT. COUNCIL, STATUS OF BOCACCIO, SEBASTES PAUCISPINIS, IN THE CONCEPTION, MONTEREY, AND EUREKA INPFC AREAS FOR 2009 18 (2009), http://www.pcouncil.org/wp-content/uploads/Bocaccio_Final_Jan15_2010.pdf. A single canary rockfish dataset was available—dating from 1980—which analyzed outer coast locations, finding low variation and equivocal evidence of geographic structuring among coastal populations. DRAKE ET AL., *supra* note 7, at 39; *see* Lisa N. Wishard et al., *Stock Separation of Five Rockfish Species Using Naturally Occurring Biochemical Genetic Markers*, 42 (3-4) MARINE FISHERIES REV. 64, 69 (1980). The little data available for greenstripe similarly suggested little structuring among coastal populations, and no genetic data were available for redstripe rockfish. DRAKE ET AL., *supra* note 7, at 39–40.

63. DRAKE ET AL., *supra* note 4, at 40.

been subject to inside-vs.-outside Puget Sound genetic studies, finding that all three showed significant evidence of distinct populations inside the Sound.[64] Subsequently, all three were declared to be DPSs.[65] A fourth species also had substantial fragmentation of its populations on either side of Vancouver Island.[66]

In sum, several other rockfish species had distinct populations between the Sound and the Coast, and these species were similar to the petitioned species with respect to life history and habitat. The available genetic data were largely silent on this question as it pertained to the petitioned species—with the arguable exception of yelloweye—but demographic and oceanographic information also suggested that the Sound populations tended to be self-contained. Consequently, given the totality of evidence from analogous species and from other circumstantial evidence, the NMFS scientists concluded that rockfish species in the area were likely to be a DPS until proven otherwise.[67]

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64. *Id.* These species are *S. auriculatus*, *S. maliger*, and *S. caurinus*, respectively.

65. HEATHER A. STOUT ET AL., U.S. DEPT. OF COMMERCE, STATUS REVIEW OF COPPER ROCKFISH, QUILLBACK ROCKFISH, AND BROWN ROCKFISH IN PUGET SOUND, WASHINGTON (2001). *See also* Petition to List Copper and Quillback Rockfishes in Puget Sound (Washington) as Threatened Species under the Endangered Species Act, 72 Fed. Reg. 2863, 2863–64 (Jan. 23, 2007) (notice of finding). Note that despite being identified as DPSs in principle, these species were not listed due to insufficient threat. *Id*.

66. DRAKE ET AL., *supra* note 7, at 40–41; this work describes the patterns of the Pacific Ocean Perch (*Sebastes alutus*), which is (confusingly) another rockfish species, rather than a perch.

67.

> Based on the earlier DPS designations for copper, quillback, and brown rockfish (Stout et al. 2001a), the [Team] generally assumed that in the absence of information indicating otherwise, the five petition[ed] species were likely to have DPSs in inland marine waters distinct from coastal populations. The reasoning for this is that the ecological and environmental factors considered by Stout et al. (2001a) and reviewed in earlier sections of this report—including the relatively site-attached nature of rockfish, the unique features of the Puget Sound/Georgia Basin ecosystem compared to the outer coast, and the environmental features of Puget Sound that serve to limit the potential for migration—all apply more or less equally to all rockfish, not just the three species considered by Stout et al. (2001a). The [Team] also noted that relatively large genetic differences have been found between inner (Puget Sound or Strait of Georgia) and outer (California Current) populations for every rockfish species for which such comparisons have been made. This suggests that the same patterns might be expected in other rockfish species, unless their life history differs in ways that may have a substantial effect on dispersal and connectivity. The [Team] therefore concluded that, *in the absence of other information, rockfish of all species that inhabit the Georgia Basin or Puget Sound are likely to meet the "discreteness" criteria of the DPS policy. . . . The [Team] also concluded that, in the absence of other information, all rockfish species in Georgia Basin or Puget Sound that are discrete are also likely to meet the "significance" criteria of the DPS policy*. . . . Puget Sound/Strait of Georgia is a unique environment, and the environmental conditions experienced by rockfish in this region are distinct from those elsewhere in their range.

Id. at 45 (emphasis added).

B. Meeting the Burden or Shifting the Burden?

Listing a new DPS demands the agency affirmatively show a vertebrate population is (1) discrete, (2) significant, and (3) threatened or endangered.[68] Here, lacking crucial information, the Team used circumstantial evidence—limited data from the petitioned species in other places, and data from analogous rockfish species in Puget Sound—to make this showing.

Depending on one's point of view, the Team's inferences might be seen either as meeting its evidentiary burden using the sum of the evidence in hand, or else as shifting the burden (from the petitioner onto itself) by assuming the existence of a DPS in the absence of evidence to the contrary. One might even question whether the agency had the authority to analogize across species, using information from non-petitioned species to make inferences about petitioned species to meet its statutory burden.

At least two arguments strongly support the agency's authority to analogize across species in this way. First, the text of the ESA gives the resource agencies the authority to list a species *sua sponte*, rather than relying upon an external petition to do so.[69] Given that NMFS had the authority to undertake a twelve-month review of its own accord, a shortcoming of information in the rockfish petition did not undercut the agency's authority to engage in the kind of analysis that it did. Second, the ESA's "best available science" requirement[70] obligates the agency to use the best information in its listing determinations. The agency has the authority—within reasonable bounds[71]—to decide what that "best" information is, and here NMFS determined that closely analogous species were the best source of data in the absence of any information more directly pertaining to the petitioned species.

Ultimately, NMFS listed yelloweye and canary rockfish as threatened, and boccaccio as endangered, on April 28, 2010.[72] The Team determined that

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68. Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act, 61 Fed. Reg. 4722, 4725 (Feb. 7, 1996) (notice of policy).

69. 16 U.S.C. § 1533(b) (2012) ("The Secretary shall make determinations . . . .").

70. *Id*. ("The Secretary shall make determinations required by subsection (a)(1) solely on the basis of the best scientific and commercial data available.").

71. For discussion on the definition and use of best available science in ESA rule making, see generally Holly Doremus, *Listing Decisions Under the Endangered Species Act: Why Better Science Isn't Always Better Policy*, 75 WASH. U. L. Q. 1029 (1997); Holly Doremus, *The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate*, 34 ENVTL. L. 397 (2004); Holly Doremus & A. Dan Tarlock, *Science, Judgment, and Controversy in Natural Resource Regulation*, 26 PUB. LAND & RESOURCES L. REV. 1 (2005); Natalie Lowell & Ryan P. Kelly, *Evaluating Agency Use of "Best Available Science" Under the United States Endangered Species Act*, 196 BIOLOGICAL CONSERVATION 53 (2016); Nell Green Nylen, *To Achieve Biodiversity Goals, the New Forest Service Planning Rule Needs Effective Mandates for Best Available Science and Adaptive Management*, 38 ECOLOGY L.Q. 241 (2011).

72. Threatened Status for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye and Canary Rockfish and Endangered Status for the Puget Sound/Georgia Basin Distinct Population Segment of Bocaccio Rockfish, 75 Fed. Reg. 22,276, 22,276 (Apr. 28, 2010) (to be codified at 50 C.F.R. pts. 223 & 224). The rule became final on July 27, 2010. *See id*.

greenstriped and redstripe rockfish had DPSs in Puget Sound, but that these segments were not experiencing population declines that placed them at risk of extinction.[73]

C. Post-Listing Reassessment

After an ESA listing, agencies must develop a recovery plan for the listed species and regularly report on the status of those species;[74] however, nothing requires agencies to generate new data. Instead, the recovery plan and the routine five-year status reviews can consist of roundups of existing information relevant to the listed species.

Here, NMFS dedicated significant time and money to evaluating its listing decisions, generating new data and applying new technology to the questions that the listing process had raised. In short, the agency set about filling gaps it had uncovered, and testing its own hypotheses about the discreteness of Puget Sound rockfish populations. Without explicitly saying so, the agency functionally embarked upon a multi-year scientific evaluation phase of an adaptive management cycle.

Following the listing decision in 2010, scientists at NMFS's Northwest Fisheries Science Center (Center) in Seattle—rather than the NMFS policy staff—became aware of a funding opportunity that encourages collaboration among the States, the National Oceanic and Atmospheric Administration (NOAA) Regional offices (that is, the policy staff), and the NOAA scientists. The scientists applied to this competitive grant program, known as NOAA's Cooperative Research Program, and received funding in 2014 for collections and genetic research to address the specific question of whether the now-listed Puget Sound rockfishes indeed constituted populations distinct from those on the outer coast.[75] In other words, they got funding to generate the data that was critically missing during the listing process.[76]

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73. *See id*. *See* DRAKE ET AL., *supra* note 4, at 132, 136.

74. The agency must "conduct, at least once every five years, a review of all species included" on the lists of threatened and endangered species. 16 U.S.C. § 1533(c)(2)(A). In addition, "[t]he Secretary shall report every two years . . . on the status of efforts to develop and implement recovery plans for all species listed pursuant to this section and on the status of all species for which such plans have been developed." *Id*. at (f).

75.

> We got funding from NOAA's Cooperative Research Program. It was funded in January 2014 and we started working (collecting fish) in April 2014 and completed all sampling in October 2015. The collaborators included Washington Department of Fish & Wildlife, NOAA Western Region, and between our Genetics Program and Ecosystem Science Program at NWFSC [NOAA's Northwest Fisheries Science Center]. We also received fin clips from Fisheries and Oceans Canada and the SWFSC [NOAA's Southwest Fisheries Science Center].

Email from Kelly Andrews, Research Scientist, Nw. Fisheries Sci. Ctr., to Ryan Kelly (Aug. 8, 2016) (on file with author).

76. This grant came in a competitive process internal to NMFS, and the competition would have included proposals across a wide range of study subjects and collaborations. It therefore seems not to

III. ESA LISTINGS AND AGENCY BEHAVIOR

The rockfish decision process cuts against a "rational actor" view of agency behavior in which the agency (1) minimizes effort at the level required by law, (2) minimizes litigation risk, and (3) acts to preserve its own discretion over future courses of action.[77] Specifically, (1) in an environment of shrinking budgets and growing mandates, NMFS chose an analytical path that was more difficult and time-consuming than maintaining the status quo would have been; (2) although the agency had good reasons for shifting the presumption of the Puget Sound populations' discreteness, maintaining the status quo would have been the less legally risky path;[78] and (3) later, in actively seeking data to reassess the listing decision, NMFS created data likely to limit its discretion over the future listing status of these species.

FWS and NMFS decline to list many species when data supporting the listing are scarce,[79] and many previous examples of unsuccessful listing petitions (and one-year decisions declining to list petitioned species) show more "typical" agency behavior in practice. Two examples will suffice to illustrate the point: a ninety-day finding in which FWS declined to review a petition to list a rare earthworm, and a far more searching FWS inquiry over the proposed listing of the wolverine.

The Palouse giant earthworm is native to eastern Washington State and parts of Idaho, although crucially, its full geographic range is unknown.[80] Although the species was described in 1897, vanishingly few specimens have been found in the recent past—two found in 2010, for example, generated national news coverage—despite considerable effort to find them.[81] In 2007, FWS declined a petition to list the worm in a ninety-day finding, not even getting to the biological review stage, in part because it is impossible to assess threats to the worm's habitat throughout its range since the worm's range is

have been an example of the agency explicitly directing funding at a listed species; rather, the fact that the proposed research was cutting-edge and had an applied focus seems to have made it competitive in the grant-making process.

77. *See supra* note 11.

78. Here, we are assuming that potential litigants opposed to the listing exist. In the rockfish case, no such litigants came forward, but the history of ESA listings is such that the agencies might reasonably expect lawsuits for any given listing or delisting decision. In general, then, we are assuming that ESA decisions to maintain the status quo are likely to engender less litigation.

79. *E.g.*, 90-Day Finding on a Petition To List the Common Thresher Shark as Threatened or Endangered Under the Endangered Species Act, 80 Fed. Reg. 11,379, 11,379 (Mar. 3, 2015) (to be codified at 50 C.F.R. pts. 223 & 224) ("We find that the petition fails to present substantial scientific or commercial information to support the identification of DPSs of the common thresher [shark] suggested by the petitioners."). *See infra* notes 81–86 and accompanying text (declining to list Palouse giant earthworm).

80. Jim Robbins, *Researchers Find Rare Giant Worm Doesn't Live Up to Its Billing*, N.Y. TIMES (Apr. 27, 2010), http://www.nytimes.com/2010/04/27/science/27earthworm.html?_r=0.

81. *Id.*

unknown.[82] A decision in the District Court for the Eastern District of Washington upheld the agency decision[83] and the Ninth Circuit affirmed,[84] holding that in light of FWS's rational basis for its conclusions, the agency did not act arbitrarily and capriciously.[85] Here, FWS's actions were consistent with the model of agency behavior set out above; the agency minimized effort and litigation risk, and preserved discretion, while still being arguably consistent with the language of the statute.[86]

The more recent case of the North American wolverine[87] (*Gulo gulo luscus*) shows the agency wrestling with the limits of its knowledge and discretion in a politically charged listing decision. There, FWS had proposed to list wolverines in the United States as a DPS in light of the species' dependence upon snowpack for reproduction. Climate projections showed snowpack declining in the U.S. territory of the species, and as such the listing would have

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82. 90-Day Finding on a Petition To List the Giant Palouse Earthworm as Threatened or Endangered, 72 Fed. Reg. 57,273, 57,275–76 (Oct. 9, 2007) (to be codified at C.F.R. pt. 17) ("So little information exists, about the population size, trends, habitat needs, and limiting factors of the giant Palouse earthworm, we could not determine if lack of regulations may pose a threat to the species. Therefore, we find that the petition does not present substantial scientific or commercial information to document that lack of regulatory mechanisms may be a factor threatening the continued existence of the giant Palouse earthworm.").

83. Palouse Prairie Found. v. Salazar, No. CV–08–032–FVS, 2009 WL 415596, at *6 (E.D. Wash. Feb. 12, 2009).

84. Palouse Prairie Found. v. Salazar, No. 09-35294, 2010 WL 2354160, at *1 (9th Cir. June 14, 2010).

85. *Id.*

86. In responding to the 2007 petition, FWS did not even reach the review stage despite closely analogous species of earthworm showing strong evidence of highly genetic fragmented population and small geographic ranges. *See generally* Andrew King et al., *Opening a Can of Worms: Unprecedented Sympatric Cryptic Diversity within British Lumbricid Earthworms*, 17 MOLECULAR ECOLOGY 4684 (2008) (showing very high spatial-genetic structuring in other earthworms). Notably, FWS did issue a positive ninety-day finding for the same species in 2010 and proceeded to a twelve-month finding in which the Service found listing was not warranted. The 2010 ninety-day finding looked to analogous species in the scientific literature and took a broader view of likely habitat and range for the Giant Palouse Earthworm. 90-Day Finding on a Petition To List the Giant Palouse Earthworm (*Driloleirus americanus*) as Threatened or Endangered, 75 Fed. Reg. 42,059, 42,063–64 (July 20, 2010) (to be codified at 50 C.F.R. pt. 17). The twelve-month finding saw the Service still lacking sufficient biological information about the species to make an informed listing decision.

> Because we cannot identify the full extent of the GPE's range or the varieties of habitat types it may use, we are unable to correlate habitat conversion with GPE abundance. Therefore, for the reasons stated above, the best available scientific information does not indicate that current or future habitat loss or fragmentation represents a threat to the species.

12-Month Finding on a Petition To List the Giant Palouse Earthworm (*Drilolerius americanus*) as Threatened or Endangered, 76 Fed. Reg. 44,547, 44,555 (July 26, 2011) (to be codified at 50 C.F.R. pt. 17). Relevant to this Article, the decision contains a passage approving of the use of analogous (or "surrogate" species) in ESA listing decisions and discusses under what conditions such surrogates might be appropriate. *Id.* at 44,553. As of 2017, no annelid (i.e., segmented worm) species is listed as threatened or endangered. *Listed Species Summary*, ENVTL. CONSERVATION ONLINE SYS., U.S. FISH & WILDLIFE SERV., https://ecos.fws.gov/tess_public/reports/box-score-report (last visited Jan. 8, 2017).

87. Defenders of Wildlife v. Jewell, 176 F. Supp. 3d 975 (D. Mont. 2016), *appeal dismissed*, No. 16-35466 (9th Cir. Oct 7, 2016). This case will surely spawn whole articles and other such commentary in the near future; here, we only briefly relate the facts as relevant to this Article.

been an acknowledgement that climate change was imperiling the species.[88] Based upon comments from several western states—given the inevitable political pressure surrounding an ESA listing decision that implicated climate change—FWS attempted to withdraw the proposed listing, citing its lack of information on the details of future snowpack and the mechanisms of the wolverine's dependence on that snowpack.[89] One might interpret this behavior as the agency acting to preserve discretion and minimize exposure to lawsuits from the various interested western states.[90]

Ultimately, FWS exceeded the limits of its discretion in a way that nicely illustrates the duty of agencies to act on the information they have, rather than the information they would like to have. The District Court for the District of Montana vacated the withdrawal, effectively ordering the agency to list the wolverine DPS.[91] In the wolverine case—unlike the earthworm example—the agency had extensive information available about the species (including habitat, range, and other salient data).[92] The court found unavailing the agency's claim that it had insufficient information to evaluate the threats to the species, essentially holding that the agency cannot ignore good data while waiting for perfect data.[93]

The larger point is that while agencies enjoy great deference with regard to their substantive judgments in ESA listing decisions,[94] this deference does not extend to ignoring useful data when it is available. And while agencies must make ESA decisions on the basis of the best available science,[95] a party cannot compel an agency to generate data *de novo* where no data exist.[96]

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88. *See id.* at 984. The polar bear listing is another such example. 12-Month Petition Finding and Proposed Rule To List the Polar Bear (*Ursus maritimus*) as Threatened Throughout Its Range, 72 Fed. Reg. 56,979, 56,969 (Oct. 5, 2007) (to be codified at 50 C.F.R. pt. 17).

89. Threatened Status for the Distinct Population Segment of the North American Wolverine Occurring in the Contiguous United States; Establishment of a Nonessential Experimental Population of the North American Wolverine in Colorado, Wyoming, and New Mexico, 79 Fed. Reg. 47,522, 47,522 (Aug. 13, 2014) (to be codified at 50 C.F.R. pt. 17); *see Defenders of Wildlife*, 176 F. Supp. 3d at 995 (discussing circumstances surrounding the withdrawal).

90. The agency was surely also under threat of a lawsuit from groups in support of the listing, given that litigation had prompted the proposed listing in the first place. *See Defenders of Wildlife*, 176 F. Supp. 3d at 980 (litigation history). As such, FWS might have weighed the risks of going to court against either pro- or anti-listing parties, and opted for the former.

91. *Id.* at 1011–1012.

92. *Id*. at 978–80.

93. *Id*. at 1000.

94. For an overview of such deference, see Emily Hammond Meazell, *Super Deference, the Science Obsession, and Judicial Review as Translation of Agency Science*, 109 MICH. L. REV. 733 (2011). For an ESA example, see Home Builders Ass'n of N. Cal. v. U.S. Fish & Wildlife Serv., 529 F. Supp. 2d 1110, 1117 (N.D. Cal. 2007) (granting deference to agency in listing California tiger salamander as threatened).

95. *See* 16 U.S.C. § 1533(b) (2012) ("The Secretary shall make determinations required by subsection (a)(1) solely on the basis of the best scientific and commercial data available.").

96. For example, in the earthworm case, FWS sets out its responsibilities in reviewing (rather than generating) the best available science to reach a twelve-month determination.

Thus in the case of the Puget Sound rockfish, NMFS had the discretion to decline to list the fishes on the basis that there was insufficient information available about the particular species in the petition. Instead, the agency chose to marshal talent and resources in order to reach a listing decision. Below in Part IV, we show how these actions reduced the probability of an erroneous listing decision, and then in Part V we assess the internal incentives that might have led NMFS to do so.

IV. Reducing the Likelihood of Error When Data Are Scarce or Absent

In the rockfish case, NMFS made a decision with very little information bearing directly on the petitioned species. The agency did so by reaching for close analogues, weighing the available evidence in light of those analogues, and then reassessing its decision in a rigorous way as it employed emerging technologies and worked to generate more data. Taken together, these actions effectively reduced the likelihood of erroneously listing—or failing to list—the petitioned rockfishes. What follows below is a discussion of some larger issues that arise in the context of decisions with extreme uncertainty. We use these issues to assess NMFS's decisions in the rockfish case in an effort to develop more general lessons for agency behavior.

A. Type I and II Error

A reasonable starting point comes from decision theory: essentially, that the probabilities and consequences of Type I vs. Type II error[97]—and, importantly, how these probabilities might change over time, given future data and innovation—influence the agency's decision. In the context of ESA listing decisions, Type I error is listing a species when it does not, in fact, warrant listing; Type II error is declining to list a species when listing is, in fact, warranted. Presumably, the agency weighs evidence consistent with its legal duties in an attempt to avoid either kind of error, with the knowledge that such errors nevertheless occur with some probability.

> As required by the Act, we considered the five factors in assessing whether the [earthworm] is endangered or threatened throughout all or a significant portion of its range. We examined the best scientific and commercial information available regarding the past, present, and future threats faced by the GPE. We reviewed the petition, information available in our files, and other available published and unpublished information, and we consulted with the most qualified GPE experts and queried universities, State agencies, conservation districts, and other entities.

12-Month Finding on a Petition To List the Giant Palouse Earthworm (*Drilolerius americanus*) as Threatened or Endangered, 76 Fed. Reg. 44,547, 44,563 (July 26, 2011) (to be codified at 50 C.F.R. pt. 17).

97. For a discussion of Type I and II errors in environmental decision making, see, e.g., Brosi & Biber, *supra* note 13, at 487.

Section 4 of the ESA is written to avoid Type I error by placing the evidentiary burden on the party wishing to list a species as threatened or endangered.[98] Where ample data exist about the species and relevant threats to its existence, the agency also avoids Type II error by conducting an accurate assessment of the data to reach a "correct" decision (that is, committing neither Type I nor Type II error). However, by declining to list a species[99] because data are scarce or absent—for example, as with the Palouse giant earthworm—the agency avoids Type I error at the direct risk of committing Type II error.[100] A lack of data means the agency has no way of gauging the probability of that error.[101]

Even so, and even in the absence of biological data, the consequences of each error type are reasonably clear. Type I error results in erroneous listing, wrongly triggering public and private restrictions surrounding the listed species and in addition costing the agency time and money. However, most of the consequences of Type I error are reversible by delisting.[102] In some cases, Type II errors may also be reversible, where they merely delay the rightful listing of a species upon re-petition.[103] On the other hand, Type II errors may plausibly result in a lost opportunity to prevent irrevocable extinction of a species.[104]

Given the potentially irreversible consequences of Type II error, we might expect a strong preference for avoiding it, despite the ESA's evidentiary burdens.[105] Some commentators have suggested that, given the nature of

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98. *See* § 1533(b).

99. Or indeed, even by declining to consider listing the species, as in cases that fail at the ninety-day stage.

100. Systematically preferring Type II error to Type I error, whether explicitly or implicitly, appears to be common in environmental regulation and governance. *See* LEE, *supra* note 14, at 173.

101. Note that data from analogous species or other prior experience would provide a way to gauge the probability of error. See *infra* Part IV.B.

102. The canary rockfish is a good example. *See* Removal of the Puget Sound/Georgia Basin Distinct Population Segment of Canary Rockfish From the Federal List of Threatened and Endangered Species and Removal of Designated Critical Habitat, and Update and Amendment to the Listing Descriptions for the Yelloweye Rockfish DPS and Bocaccio DPS, 82 Fed. Reg. 7711, 7711 (Jan. 23, 2017) (to be codified at 50 C.F.R. pts. 223 & 224) (final delisting of canary rockfish).

103. Here again, the rockfish provides a useful example, given that it took more than one petition before the agency reached a positive ninety-day finding. This happens for many species as new information becomes available.

104. A 2004 review by the advocacy organization Center for Biological Diversity found forty-two species that had gone extinct while awaiting listing. KIERAN SUCKLING ET AL., CTR. FOR BIOLOGICAL DIVERSITY, EXTINCTION AND THE ENDANGERED SPECIES ACT 22 (2004), http://www.biologicaldiversity.org/publications/papers/ExtinctAndESA.pdf. Note that it was not the failure to list that resulted in the extinction, but rather the failure to list that resulted in a missed opportunity to prevent the extinction. Note also that some of the species in the cited report are disputed. For example, the Amak Island song sparrow appears not to be a species distinct from other similar song sparrows. *See* Christin L. Pruett et al., *Amak Island Song Sparrows (Melospiza Melodia Amaka) are Not Evolutionarily Significant*, 3 ORNITHOLOGICAL SCI. 133, 133–35 (2004).

105. And indeed, case law supports this idea to some extent. *Tennessee Valley Authority v. Hill* is the most obvious example: if the value of any given species is "quite literally, incalculable," then

species extinction as irrevocable harm to humanity and ecosystems, agencies should always err on the side of listing species.[106] However, the ESA itself is clear in its allocation of burdens: one must affirmatively demonstrate that a species merits listing, and hence as written the ESA avoids Type I error while risking Type II. This allocation of burdens is likely to completely drive outcomes where little or no data are available. Therefore, many "not warranted" findings result from a lack of sufficient data rather than any real evidence of a petition's merits.[107] The new FWS prioritization scheme[108] reinforces this setup; species with little information are at the bottom of the pile, regardless of their other merits (e.g., vulnerability to extinction, ecological role, cultural importance, or evolutionary significance). All of this context makes the rockfish example—in which existing information on analogous species led NMFS to risk Type I error in order to minimize Type II error[109]—more intriguing.

B. Reaching for Close Analogues

In the ESA context, information from closely analogous species offers the agencies a starting point for analysis where—perhaps by the very nature of a species' rarity—data on petitioned species is lacking. Agencies must use the best available science, but generally draw the line inside of the species boundary. Here, NMFS looked to other members of the rockfish genus in the same time and place. FWS, by contrast, did no such thing in the earthworm case, despite good evidence of genetic fragmentation in other similar species.[110]

Naturally, reliance on analogues presents a gray area: how similar (and how similar along which axes) must a species be in order for comparisons to be informative? Exercising this sort of judgment, however, is precisely what agencies are empowered to do. NMFS and FWS weigh more- and less-relevant

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avoiding a probability of losing that species—even at great cost—becomes rational. 437 U.S. 153, 177 (1978).

106. KRISTIN SHRADER-FRESHETTE, ETHICS OF SCIENTIFIC RESEARCH, 106-16. (1994).

107. This is almost by definition. The ninety-day finding asks whether the petition contains sufficient information to suggest that listing may be warranted, and so any petition that contains little data is likely to fall short of meeting its burden. The newly published FWS prioritization scheme enshrines this problem into policy. Draft Methodology for Prioritizing Status Reviews and Accompanying 12-Month Findings on Petitions for Listing Under the Endangered Species Act, 81 Fed. Reg. 2229, 2231 (Jan. 15, 2016) (prioritizing species for which more information is available might be a rational allocation of resources on the part of the agency, but it at least bears scrutiny in the context of a law that (in theory) treats all plant and animal species equivalently).

108. 81 Fed. Reg. at 2231.

109. And indeed, subsequent reanalysis found it had committed Type I error. *See* Removal of the Puget Sound/Georgia Basin Distinct Population Segment of Canary Rockfish From the Federal List of Threatened and Endangered Species and Removal of Designated Critical Habitat, and Update and Amendment to the Listing Descriptions for the Yelloweye Rockfish DPS and Bocaccio DPS, 82 Fed. Reg. 7711, 7711 (Jan. 23, 2017) (to be codified at 50 C.F.R. pts. 223 & 224).

110. *See* King et al., *supra* note 86, at 4685.

information all the time when assessing risk to protected and managed species, when developing population models, and so forth. Administrative agencies function similarly across the spectrum of governmental duties, from establishing health guidelines ("Is chocolate milk more like milk, or more like dessert?") to developing drug-safety regulations ("Is this whole class of drugs dangerous, or just this particular drug?") and everywhere in between.[111] In the judicial branch, of course, courts do the same analysis as a core part of their jobs, weighing precedent as it may apply to the particular facts at hand. More tenuous analogues are likely to be less compelling.[112]

The ESA demands agencies use the information at their disposal and not ignore any better information, as the wolverine case reminds us. The statute does not demand perfection,[113] which is fortunate, since perfection is not on offer in scientific data or elsewhere. Here, the rockfish analogues were compelling enough to cause NMFS to shift the presumption against discreteness; data existed for closely related fishes and for other fishes with similar distributions, and the bulk of this evidence suggested the Puget Sound rockfish were likely to be distinct from their outer coast relatives. Had FWS reached for data to help itself evaluate the earthworm petition, it would have reached the same conclusion. However, the Ninth Circuit's decision upholding FWS's denial of the earthworm petition suggests that courts will not require agencies to look beyond the petitioned species for information about that species' range or biology. It therefore seems that analogues are acceptable and often useful—but probably not required—where data on petitioned species are scarce.[114]

C. Targeted Reassessment of Listing Decision

In addition to using analogues, reassessing previous decisions is an additional way to reduce the likelihood of error[115] and is another hallmark of adaptive management. As described above in Part II, an opportunity arose in 2014 to test the population-discreteness inferences NMFS had made leading up to the 2010 listing decision.

111. *See, e.g.*, *What We Do*, U.S. FOOD & DRUG ADMIN., http://www.fda.gov/AboutFDA/WhatWeDo/ (last updated Oct. 24, 2016) (providing an example of an agency discussing its mission).

112. Note that in a highly controversial and public case, the audience gauging the merits of an asserted analogy might be the press, the public, or (ultimately) a judge. In lower-profile cases—that is, those not generating litigation—it is likely to be scientists and other agency staff weighing the merits of an analogical claim. Thus the degree to which analogous data is compelling or relevant might vary depending upon the species or issue at hand.

113. *See* Defenders of Wildlife v. Jewell, 176 F. Supp. 3d 975, 1000 (D. Mont. 2016), *appeal dismissed*, No. 16-35466 (9th Cir. Oct 7, 2016) (citing with approval earlier cases that made this assertion about the statute not requiring perfect information).

114. Note that the use of analogues lends such decisions the flavor of adaptive management or Bayesian decision making; analogues create a prior expectation that can be tested against new data.

115. That is, to reduce the likelihood that the agency decision is, in the end, incongruent with facts on the ground. Another way of thinking about this is that reassessment mitigates any harm done by the original misclassification of the species by reducing the duration of that error.

To this end, NMFS scientists[116] partnered with recreational fishers and the State of Washington to gather the tissue samples necessary to conduct an analysis on population discreteness. The line-level scientists initiated the project, without initial prompting by more senior NMFS personnel, and the fact that the target species were ESA-listed appears to have been beside the point; the project's main driver was the eminently testable hypothesis that populations were genetically distinct inside vs. outside Puget Sound.[117]

The resulting conclusions led NMFS to propose delisting the canary rockfish—on the agency's own initiative—because the newly available genetic data provided no indication that inside populations were different from those outside.[118] By finalizing the rule,[119] NMFS has successfully limited the impacts of a Type I error (that is, an erroneous listing). At the same time, the new data indicated that yelloweye rockfish indeed have distinct populations, and that the inferences NMFS made from analogous species were correct. Hence, the agency avoided Type II error (an erroneous failure to list) by using analogous data in the 2010 listing decision.[120]

Courts are unlikely to require this kind of targeted reassessment of key prior decisions. How, after all, should one decide which of the many prior decisions merit reassessment?[121] Moreover, courts rightly defer to agency expertise and judgment in most cases, and few judges are likely to second-guess an agency's individual scientific judgments. As with the use of analogous

116. Kelly Andrews (Research Scientist, NMFS's Northwest Fisheries Science Center), Krista Nichols (Research Geneticist, NMFS's Northwest Fisheries Science Center), and colleagues.

117. This is the personal observation of one of the authors of the present paper, Phil Levin, who was the Director of the Conservation Biology Division at NOAA's Northwest Fisheries Science Center at the time the project we describe here took place.

118. Removal of the Puget Sound/Georgia Basin Distinct Population Segment of Canary Rockfish From the Federal List of Threatened and Endangered Species, and Removal of Designated Critical Habitat, and Update and Amend the Listing Descriptions for the Yelloweye Rockfish DPS and Bocaccio DPS, 81 Fed. Reg. 43,979, 43,979 (July 6, 2016) (to be codified at 50 C.F.R. pts. 223 & 224). Note that NOAA's Western Region, its policy arm, was aware of the genetics work by the NOAA scientists as a result of the cooperative structure of the funding mechanism supporting the genetics work. *See* Email from Kelly Andrews, *supra* note 75 (describing the list of collaborators on the genetics project). The picture that emerges is a greater separation of science and policy during the analyses involved in the listing process, and a somewhat less stringent separation of these science and policy institutions during subsequent, science-led reanalysis.

119. Removal of the Puget Sound/Georgia Basin Distinct Population Segment of Canary Rockfish From the Federal List of Threatened and Endangered Species and Removal of Designated Critical Habitat, and Update and Amendment to the Listing Descriptions for the Yelloweye Rockfish DPS and Bocaccio DPS, 82 Fed. Reg. 7711, 7711 (Jan. 23, 2017) (to be codified at 50 C.F.R. pts. 223 & 224).

120. The third listed DPS—bocaccio—remains sufficiently rare that the NMFS reassessment could not gather enough data to test the discreteness hypothesis. 81 Fed. Reg. at 43,982 ("Bocaccio are rare within the DPS area and we were able to obtain only a few samples of them in the genetic study. Because of their rarity, the genetic analysis for bocaccio included only two samples from within the DPS area, and this is not sufficient information to change our prior status review determination that Puget Sound/Georgia Basin bocaccio are discrete from coastal fish.").

121. This problem is also likely to be one reason that adaptive management can prove difficult to implement in practice.

data, targeted reassessments are again likely to be helpful—but not required—ways of reducing agency error.

D. Strategically Delaying a Decision

A third (and common) strategy for reducing error at any given decision point—but one that NMFS did not employ in the rockfish case—is to delay a decision in the hopes that more data will become available. Declining to list a species is, of course, a decision itself; the agency determines that the available evidence does not merit changing the status quo. But so long as the petitioned species does not go extinct in the meantime, the agency may later take up another petition to list the same species.[122] Therefore, we might view a negative ninety-day finding or listing decision as a delay and a provisional maintenance of the status quo.[123] The ESA also includes a mechanism for an explicit delay in the case of "substantial disagreement" over the available data in a listing decision.[124]

Given this decision point—whether to list a species under the ESA or preserve the status quo—and given that information in hand is critically scarce, when is it rational for an agency to decline to list on the basis of insufficient information? The legal answer is straightforward: an agency declines to list a species whenever the information in hand is not sufficient to indicate that the species is in danger of becoming extinct (endangered) or likely to become so (threatened).[125] But this formalism merely enshrines the agency's discretion to

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122. As, indeed, has happened many times, including with previous petitions surrounding the rockfish themselves. *See*, *e.g.*, Petition to List Five Rockfish Species in Puget Sound (Washington) as Endangered or Threatened Species under the Endangered Species Act, 72 Fed. Reg. 56,986, 56,988 (Oct. 5, 2007) (notice of finding) (finding that previous petition to list the same five rockfish species was not warranted).

123. A positive listing decision often triggers subsequent rulemakings and reviews, and so is not so easily revisited as a negative listing decision. For two examples of such rulemakings following ESA listings, see 90-day Finding for a Petition to Revise Designated Critical Habitat for Elkhorn and Staghorn Corals, 74 Fed. Reg. 36,995, 36,995 (July 27, 2009) (to be codified at 50 C.F.R. pt. 226) (designating critical habitat for two species of corals) and Designation of Critical Habitat for the Black Warrior Waterdog, 69,475, 69,475 (Oct. 6, 2016) (to be codified at 50 C.F.R. pt .17) (proposing critical habitat for the Black Warrior Waterdog salamander).

124.

> If the Secretary finds with respect to a proposed regulation referred to in subparagraph (A)(i) that there is substantial disagreement regarding the sufficiency or accuracy of the available data relevant to the determination or revision concerned, the Secretary may extend the one-year period specified in subparagraph (A) for not more than six months for purposes of soliciting additional data.

16 U.S.C. § 1533(b) (2012).

125.

> The term 'endangered species' means any species which is in danger of extinction throughout all or a significant portion of its range other than a 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. § 1532(6). The term 'threatened species' means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

determine what is sufficient in any given case, and as the contrasting outcomes of the earthworm and rockfish analyses show, such textual analysis can be a poor predictor of agency decisions in practice.[126]

Identifying sufficient information is all the more problematic in the context of a world in which technology is constantly changing (and, one hopes, improving), such that there is always hope that delaying a decision might allow for the use of more and better information at a later date. Whether in the context of ESA listings or more broadly in administrative law, when (if ever) is it reasonable for an agency to delay a decision in the hopes that the future will bring more information?

Delay is rational when future events are likely to meaningfully reduce uncertainty over a timescale relevant to the decision at hand, and is irrational otherwise.[127] As applied to ESA listings, the relevant timescales are often short,[128] and so on one hand, it seems unwise for an agency to delay a listing decision for lack of data unless the agency then undertakes targeted research to remedy the shortfall. On the other hand, given the evidentiary burden that the ESA expressly allocates to the petitioner or to the agency to affirmatively demonstrate the case for listing, the agency cannot act in the complete absence of information.[129]

Emerging technology can help fill in data gaps, particularly where information is scarce due to limitations on time, people, and money. But where there is not a well-founded reason to believe new data will arrive in a time frame relevant to the decision at hand, delaying a decision is irrational.[130] As a result, the march of technology is not a reason to punt on decisions now, but rather a reason to consider many decisions provisionally valid until shown to be otherwise. This is precisely what NMFS did in the rockfish listing. As in the

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§ 1532(20).

126. For example, see Defenders of Wildlife v. Jewell, 176 F. Supp. 3d 975 (D. Mont. 2016), *appeal dismissed*, No. 16-35466 (9th Cir. Oct 7, 2016), litigation over the wolverine's listing, in which case the threshold of sufficiency appeared to shift at different stages of the petition process.

127. *See, e.g.*, COMMITTEE ON SCIENTIFIC ISSUES IN THE ENDANGERED SPECIES ACT BD. ON ENVTL. STUDIES & TOXICOLOGY, COMM'N ON LIFE SCIS., NAT'L RESEARCH COUNCIL, SCIENCE AND THE ENDANGERED SPECIES ACT 159 (1995) ("Sometimes, it is possible to delay action while gathering better information, although that strategy carries its own risks. Sometimes, important factors affecting how management actions turn out, such as catastrophic weather conditions or pollution accidents, are inherently uncertain, and no amount of further study could do more than improve the accuracy and precision of estimates of their likelihoods.").

128. The polar bear listing, for example, used a forty-five-year time frame. *In re* Polar Bear Endangered Species Act Listing and § 4(d) Rule Litig., 794 F. Supp. 2d 65, 75 (D.D.C. 2011). Given the decades-long lifespan of an individual bear, this seems a relatively short time horizon.

129. As indeed NMFS did not act in the complete absence of information here: the petition demonstrated that rockfishes, as a whole, were steeply declining in Puget Sound, and this was enough to trigger the affirmative ninety-day finding. Note that the alarm triggered by a "steep" population decline may depend upon the relevant biological time frames of the species involved.

130. And therefore, likely arbitrary and capricious under the Administrative Procedure Act, 5 U.S.C. § 706(2)(A) (2012).

wolverine case, the agency may not permissibly make the perfect the enemy of the good.[131]

Political pressure surely matters, too. As the contrasts among the rockfish, earthworm, and wolverine examples make clear, agencies exercise significant discretion when faced with scarce data, and the particular factors influencing any given decision—for example, political pressure from environmental non-governmental organizations, commercial fishing interests, or farmers in Eastern Washington or other western states—vary with context.[132] Precisely because the rockfish listing had a low political profile and did not trigger legal challenges, it provides an example of how agencies make decisions when data are scarce and when those agencies are away from the spotlight of politics.

ESA decisions—like all administrative-law decisions—take place against a backdrop of risk management and political interest driven in part by the differential distributions of costs and benefits. Where data are scarce or absent, the risks of Type I and Type II error do not change—and neither do the distributions of costs and benefits, if realized—but our ability to assess the likelihood of those errors goes down. Accordingly, the default rules and processes become more important. Moreover, internal agency incentives begin to dominate the exercise of discretion. The following Part briefly evaluates the incentives of the NMFS scientists in the rockfish listing, in an effort to develop insights relevant to federal agencies more generally.

V. AGENCY INCENTIVES: WHY DID NMFS DO WHAT IT DID?

Having thus described the rockfish decision in the larger context of other ESA decisions and in terms of risk management, the key question remains. Why did NMFS act in this way when it did not have to? And—given that this is a single data point of agency behavior—are there more general observations that we can glean from the rockfish example? Three related observations stand out as factors plausibly contributing to the agency's behavior: institutional design, tractable analytical opportunity, and newly available technology. We address these in turn below, before addressing more general lessons for agency behavior under highly uncertain conditions in the subsequent Part.

131. *See* Defenders of Wildlife v. Jewell, 176 F. Supp. 3d 975, 1011 (D. Mont. 2016), *appeal dismissed*, No. 16-35466 (9th Cir. Oct 7, 2016).

132. Even the cases we discuss in this Article provide examples of this difference in political context. While the rockfish listing did not trigger litigation (in part because state regulations had earlier curtailed commercial fishing for rockfish in Puget Sound, thus leaving few stakeholders with an interest in challenging the listing), the objections of the western states appeared to influence the listing process in the wolverine case in a significant way. *See supra* Part III. Nearly every ESA listing decision features a combination of idiosyncratic political factors that can result in litigation or otherwise influence the listing process.

A. Separation of Science and Policy at NMFS

It seems clear that the structure of NMFS played a significant role in driving the inquiry-based behavior leading to the rockfish listing. The agency cleanly separates its scientific arms from its policy arms, functionally separating fact finding from decision making. In Seattle—where this story takes place—the Northwest Fisheries Science Center consists of about 300 scientists on a dedicated campus several miles from the Western Regional Office, which decides policy. This geographic separation accompanies functional separation and distinct chains of command. Rather than reporting to policy-driven higher-ups at the regional office, Center scientists report to the Center's Science Director, who reports to the NMFS Chief Scientist, who in turn reports to the Assistant Administrator for Fisheries in Washington D.C. This last position is a political appointment; the others are career staff. The most senior person on the rockfish BRT[133] was five steps from the nearest political appointee.

When a petition for listing arrives at the Regional Office, it leaves the policy arm of NMFS and goes out to appropriate scientists for review.[134] These scientists provide their assessment of the petition to the Regional Office, which then makes the ninety-day finding that the listing may either be warranted or that it does not warrant further analysis. In the case of a positive ninety-day finding, the leadership of the Northwest Fisheries Science Center (the scientific leadership) forms an ad-hoc BRT of federal scientists, who are left to guide their own inquiries.[135] Following these inquiries, the BRT issues a recommendation as to relevant findings of fact (discreteness and significance, population size and trends, and threats to the species) rather than a listing recommendation (a policy decision). This is not to say that value judgments do not play a role in the scientific deliberations, but rather to point out an institutional design that attempts to separate scientific inquiry from the policy decision.[136]

133. This is the personal observation of one of the authors of the present paper, Phil Levin, who was the Director of the Conservation Biology Division at NOAA's Northwest Fisheries Science Center and the most senior person on the BRT. The description of these procedures in the present paragraph of the main text arises from personal experience. The relevant chain of command was as follows: Levin, Division Director (Fishery Resource Analysis and Monitoring Division, Northwest Fisheries Science Center), Center Deputy Science Director, Center Science Director, Chief NMFS Scientist, Assistant Administrator. All officials below Assistant Administrator are career agency staff.

134. Personal observation; see *supra* note 117. The reviewing scientists within the agency are not allowed to gather additional data.

135. While the Region may attend review team meetings and guide scientists on procedure, the scientists do the data gathering and deliberation.

136. Consistent with this idea, in interviews, scientists involved in the rockfish process repeatedly emphasized curiosity, problem-solving, and the search for knowledge as the driving forces in the analysis by the BRT and its reassessment. Interview with Kelly Andrews, Res. Fishery Biologist, Northwest Fisheries Science Center (Feb. 23, 2016); Interview with Greg Williams, Res. Fishery Biologist, Northwest Fisheries Science Center (Feb. 23, 2016); Interview with Nick Tolimieri, Res.

This institutional structure perhaps dampens the kind of risk-and-effort minimization and discretion maximization we might otherwise expect from a federal agency. To the extent that agency scientists are encouraged to be inquiry driven rather than policy driven—that is, to the extent they are allowed to be scientists, motivated by curiosity and the rewards of publishing novel findings—we might expect more data-driven conclusions.

FWS, the other agency that implements the ESA, has far less separation of science and policy. Although FWS makes use of external peer reviewers for its scientific findings, the agency does not have physically separate scientific and policy offices, and neither are these functions organizationally separated.[137] Other federal agencies separate scientific and policy functions to varying degrees; the breakup of the former Minerals Management Service into subagencies with nonconflicting functions is the highest-profile example of such separation (in that case, borne of scandal), but few others appear to have the kind of functional separation that NMFS does.[138]

Fishery Biologist, Northwest Fisheries Science Center (Feb. 23, 2016); Interview with Mike J. Ford, *supra* note 60.

137. "But we do consciously distinguish in the process of making an ESA listing determination between the scientific analysis of the current status and projected future condition of a species, and the policy determination of whether the species meets the definition of a threatened or endangered species." Email from Gary Frazer, Assistant Dir. for Endangered Species, U.S. Fish & Wildlife Serv., to Ryan Kelly (May 11, 2016) (on file with author). Interestingly, Frazer pointed to the reorganization of the Department of Interior—in which many of FWS's scientists passed through the short-lived National Biological Survey and ultimately ended up in the United States Geological Survey (USGS)—as the reason that FWS "no longer has a distinct science or research program." *Id.*

138. USGS and the Bureau of Reclamation do scientific work that is not explicitly regulatory, and one might see these agencies as separating out functions with potentially conflicting roles within the larger Department of the Interior, to which both agencies (and FWS) belong. USGS has external peer-review policies and related documentation. *Office of Science Quality and Integrity*, U.S. GEOLOGICAL SURVEY, https://www2.usgs.gov/quality_integrity/ (last visited Jan. 8, 2017). Other agencies have similar rules, and the White House Office of Science and Technology Policy issued a memorandum to the heads of executive departments and agencies in 2010 regarding scientific integrity, noting that "[s]cience . . . thrives in an environment that shields scientific data and analyses from inappropriate political influence; political officials should not suppress or alter scientific or technological findings." Memorandum from John P. Holdren on Sci. Integrity to the Heads of Exec. Dep't & Agencies 1 (Dec. 17, 2010), https://www.whitehouse.gov/sites/default/files/microsites/ostp/scientific-integrity-memo-12172010.pdf. This memo appears to have followed from President Obama's inaugural address in 2009, in which Obama vowed to "restore science to its rightful place" following the perceived shortcomings of the Bush administration in this regard. *See Basic Information about Scientific Integrity*, OFFICE OF THE SCI. ADVISOR, EPA, https://www.epa.gov/osa/basic-information-about-scientific-integrity#commitment (last visited Jan. 9, 2017). The U.S. Forest Service, within the Department of Agriculture, has a Forest Service Research Program Unit that is distinct from the management-level National Forest System. *Agency Organization*, U.S. FOREST SERV., http://www.fs.fed.us/about-agency/organization (last visited Jan. 8, 2017). NOAA has a Science Integrity Officer and a fairly extensive set of documents available in their online science integrity "commons." *Scientific Integrity Commons,* NOAA RESEARCH COUNCIL, http://nrc.noaa.gov/ScientificIntegrityCommons.aspx (last visited Jan. 9, 2016).

B. Low-Hanging Analytical Fruit

Given the helpful institutional design elements at NMFS that created space for the agency's scientists to do science, the rockfish Team also appears to have welcomed the opportunity to deploy and advance an emerging statistical method. NMFS scientists—particularly, one rockfish Team member, Eli Holmes—had already been working on a statistical method to piece together sparse data on species' abundances from different sources to reveal larger trends over time.[139] In the rockfish case, such a piecing together was exactly the task the Team had to undertake in sorting out species abundances before and after fishing regulations had attempted to limit the decline of Puget Sound rockfish.[140] The Team knew rockfishes (as a group) were declining in abundance in Puget Sound, but was this true of the petitioned species in particular?

The existence of a new technique well suited to filling a critical information gap motivated the scientists to conduct innovative analyses beyond what a court would have required. That is, the rockfish petition presented a sufficiently tantalizing biological and statistical problem for NMFS scientists whose scientific curiosity drove them towards a conclusion.[141] But this wasn't idle curiosity; the scientists had a reasonable expectation that the problem was solvable. They saw a path to wringing the necessary insight from sparse data.[142]

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139. *See, e.g.*, Elizabeth Eli Holmes et al., *A Statistical Approach to Quasi Extinction Forecasting*, 10 ECOLOGY LETTERS 1182 (2007); Elizabeth E. Holmes, *Estimating Risks in Declining Populations with Poor Data*, 98 PROCEEDINGS OF THE NAT'L ACAD. OF SCI. 5072 (2001); Eric J. Ward et al., *Inferring Spatial Structure from Time-Series Data: Using Multivariate State Space Models to Detect Metapopulation Structure of California Sea Lions in the Gulf of California, Mexico*, 47 J. OF APPLIED ECOLOGY 47 (2010). Note that a critical component of this work is assessing the uncertainty surrounding estimates of population trends, especially given that uncertainty is likely to be high when data are scarce.

140. Despite good evidence of a severe decline in rockfishes overall in Puget Sound, in assessing the threats to the petitioned species, the Team needed to determine whether the petitioned species, in particular, were declining in population. The statistical technique we mention above created a framework that brought together diverse (but individually weak) strands of evidence to determine that the trend in the to-be-listed species was more severe than that of rockfishes in Puget Sound overall.

141. BRT member Nick Tolimieri, Rockfish Status Review (DRAKE ET AL., *supra* note 4) coauthor Greg Williams, and Rockfish Recovery Team member Kelly Andrews, roundly concurred that this was the primary reason the Team's analyses proceeded as they did, citing a tantalizing scientific problem and "great problem solvers in the room." Interview with Kelly Andrews, *supra* note 136; Interview with Greg Williams, *supra* note 136; Interview with Nick *supra* note 136.

142. Apart from the institutional incentives at play here—presumably, the scientists were happy to have an interesting problem to solve and fulfill the agency's role in informing policy—the individual scientists likely had personal incentives to publish their work and receive professional recognition that would help them advance their careers. One might see this as an additional set of factors animating NMFS's behavior in the rockfish case. One might also ask why, if FWS scientists also have individual incentives to publish, we do not see similar institutional behavior at FWS. We suggest that one answer lies with the large number of listed species and listing petitions FWS manages, as well as the Clinton-era reorganization of FWS such that many of its scientists ended up within USGS.

C. Available Technology Awaiting Deployment

If one accepts that the NMFS scientists were largely driven by inquiry, a similar incentive then explains the 2014-2016 targeted reassessment of the listing decision using newer genetic techniques. In the words of the principal NMFS scientist collecting the new specimens for genetic analysis, the decision to seek the genetic information was "a no-brainer."[143]

In the years between 2010 (when NMFS made the DPS determinations) and 2014 (when the scientists received funding to test the validity of those determinations), the cost of DNA sequencing had declined dramatically,[144] and it had become possible to look at thousands of genetic markers with relative ease. This gave the scientists great power to detect genetic subdivisions of the kind that would substantiate (or falsify) the DPS designation. By 2014 all of the tools were in place to collect the data and to do the analysis, and the 2010 DPS determination had set the hypothesis up perfectly. For the scientists, the missing data and analysis were valuable and attainable, creating a prime opportunity.[145]

Together, these three incentives—institutional design, the use of a newly developing analytical technique, and the existence of as-yet-unused technological solutions to the problem at hand—conspired to drive the agency to act in a way that is surprising in the larger context of administrative law.

VI. COMMUNITY-WIDE LEARNING, BENEFICIAL REDUNDANCY, AND ADAPTIVE MANAGEMENT

We suggest that the kind of reasoned process in which NMFS engaged is a positive example of federal rule making grounded in robust scientific inquiry. Below, we draw parallels between the NMFS process and other forms of learning in large organizations in an effort to develop larger lessons for federal decision making—particularly in the context of data-poor reasoning.

The Puget Sound rockfish case illuminates how learning can take shape in a large organization such as NMFS. The agency makes a set of decisions initially and puts them into effect. Scientists, some within the agency's research arm, develop novel methods so that new data can illuminate the decisions that have already been made. The researchers conduct this analysis, and the agency revises its regulatory decisions in light of the augmented scientific record. Thus the structural—if incomplete—separation between the policy and research arms

143. Interview with Kelly Andrews, *supra* note 136.

144. *See Cost Per Raw Megabase of DNA Sequence,* NAT'L HUMAN GENOME RES. INST., https://www.genome.gov/images/content/costpermb2015_4.jpg (last visited Jan. 9, 2017).

145. Krista Nichols at NMFS's Northwest Fisheries Science Center took the lead on next-generation DNA sequence analysis of the rockfish data, in collaboration with Kelly Andrews. *See* Kelly Andrews & Krista Nichols, Nat'l Oceanic and Atmospheric Admin.'s Nw. Fisheries Sci. Center, All Hands On Deck: Cooperative Research Sheds Light On Status of ESA-Listed Rockfish Populations (2016), http://cedar.wwu.edu/ssec/2016ssec/species_food_webs/3/.

of the agency creates *beneficial* redundancy[146] that can inspire the form of adaptive management seen here, in addition to paying institutional dividends in other ways.

The healthcare industry provides a useful analogue for illustration, in which multiple parties working on partially overlapping elements of the same large problem arrive at a kind of negotiated solution. The pattern is as follows. Physicians adopt a therapy or diagnostic technique, even though its ramifications are not fully understood. Interested parties other than the original physicians then proceed with research and monitoring, leading to a different understanding of the original problem; the physicians' practice then adapts to embrace the new knowledge. The incentive for all parties is a mix of professional advancement, profit, discovery, and altruism; the result is community-wide learning. Concrete examples of this pattern include the development of hormone-replacement therapy, the diagnosis and treatment of prostate cancer, and the development of public warnings about dietary choices.[147]

Sometimes, the research following a treatment decision focuses on monitoring the population being treated, using epidemiological means. In a second model of action, however, the findings that produce community-wide learning emerge from largely independent sources, such as the development of imaging techniques that enabled diagnosticians to see the body in new and different ways. In the Puget Sound rockfish case, the agency's learning followed the latter model. After the 2010 listing, the availability of new genetic techniques led a different set of researchers to collect new data. The analysis of these data added scientific insights to the 2010 listings, leading the agency to revise the earlier listings.

The rockfish case is thus an interesting variant on adaptive management, although neither the scientists involved nor the NMFS policy staff in the Western Region were thinking of the case in such terms.[148] In light of additional knowledge, the earlier decisions to list several species were reexamined and changed as appropriate in light of the new understanding. It is important to note, however, that the decision-making process (that is, the rockfish ESA listing process within NMFS) was not designed to test whether

146. *See* Jonathan Bendor, *Incrementalism: Dead Yet Flourishing*, 75 PUB. ADMIN. REV. 194, 200 (2015).

147. *See, e.g.*, Denise Grady, *Earlier Hormone Therapy Elevates Risk of Breast Cancer, Researchers Say*, N.Y. TIMES (Jan. 28, 2011), http://www.nytimes.com/2011/01/29/health/29hormone.html; Denise Grady, *Flawed Study of Advanced Prostate Cancer Spreads False Alarm*, N.Y. TIMES (July 20, 2016), http://www.nytimes.com/2016/07/21/health/advanced-prostate-cancer-false-alarm.html; L. S. A. Augustin et al., *Associations of Bread and Pasta with the Risk of Cancer of the Breast and Colorectum*, 24 ANNALS OF ONCOLOGY 3094 (2013).

148. To some extent, the case shows why such data-poor decisions are *necessarily* adaptive, given that all information is incomplete and that scientific inference tends to improve over time.

the 2010 listings were appropriate under ESA.[149] Instead, new knowledge was generated via a process of funding and organizational attention that operated independently of the policy process. Yet when the scientists produced new knowledge, the policy arm of NOAA undertook, on its own initiative, a revision of the rules it had promulgated.[150]

The structural separation between the policy and science arms in NMFS made room for independent inquiry,[151] motivated by the scientific staff's sense of what was interesting and valuable research. At the same time, some cooperation among researchers and policy staff encouraged scientific inquiry focused on issues relevant to policy.[152] This is use-inspired research, in which users and producers of knowledge coproduce results that are both useful in decision making and scientifically interesting.[153]

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149. Indeed, the response of the rockfish populations being protected is slow because of the slow reproductive rate of the species (*See, e.g.*, WAYNE A. PALSSON ET AL.,WASHINGTON DEPT. OF FISH AND WILDLIFE, THE BIOLOGY AND ASSESSMENT OF ROCKFISHES IN PUGET SOUND 1-1 (2009), *wdfw.wa.gov/publications/00926/wdfw00926.pdf* ("[r]ockfish grow slowly, have a long life span, have low natural mortality rates, mature late in life, [and] have sporadic reproductive success from year to year," the result of which is a slow net population growth rate), and the data are noisy because the populations are sparse. So, the usual paradigm of adaptive management does not apply, in which policy and management respond to monitoring of the natural systems of concern, preferably with minimal time lag between management decision (cause) and outcome (effect).

150. If one sees this as a means of husbanding the limited legitimacy of top-down decision making, then it would be useful to study whether revisions are made (a) when Type I error has led to sunk costs among stakeholders and within the agency; and (b) when there is lingering conflict over the original decision. In the rockfish case there was no external controversy, either in 2010 or in the more recent reconsideration of the listings. In biomedicine, on the other hand, changes in recommended practices have sometimes been controversial. *See, e.g.*, Gina Kolata, *Mammogram Debate Took Group by Surprise*, N.Y. TIMES (Nov. 20, 2009), http://www.nytimes.com/2009/11/20/health/20prevent.html; Grady, *supra* note 147. It may be that either of these conditions saps the agency's will to correct its earlier decisions, but that is an empirical question worth probing, given the widespread perception that government regulation is unnecessarily burdensome.

151. The organizational separation of policy and science in this case resembles the analysis of monitoring provided by Professor Eric Biber, who notes that when monitoring is funded by the agency whose policy implementation is being monitored, there is a risk that the results or process will be skewed by the policy preferences or bureaucratic interests of the agency. Eric Biber, *The Problem of Environmental Monitoring*, 83 U. COLO. L. REV. 1, 51–52 (2011). Yet when monitoring is conducted by an independent entity, that entity may have difficulty sustaining its funding, even though long-term datasets are often the most valuable product of a monitoring program. *Id.* at 70. There is no simple or general solution to this tension.

152. Note the collaboration between the Western Region (policy) and NMFS scientists on the genetics survey. Email from Kelly Andrews, *supra* note 75. The rockfish recovery team consists of a mixture of academic and agency personnel from state and federal agencies. *Rockfish Recovery Team Members*, NOAA FISHERIES, http://www.westcoast.fisheries.noaa.gov/protected_species/rockfish/rockfish_recovery_team_members.html (last visited Jan. 9, 2017).

153 William C. Clark et al., *Crafting Usable Knowledge for Sustainable Development*, 113 PROCEEDINGS OF THE NAT'L ACAD. OF SCI. 4570, 4571 (2016). Yet the rockfish case is an unorthodox example of use-inspired research. The link between action (policy choice) and knowledge production (research) was institutional rather than problem-focused—the coproduction of usable knowledge was prompted by a use anticipated by the researchers rather than the policy actors. Yet it was apparent to both policy and scientific staff that results clarifying the relationships between Puget Sound and coastal populations would be useful and would constitute a "boundary object" of significance in the decision process. *See* William C. Clark et al., *Boundary Work for Sustainable Development: Natural Resource*

These unusual features of the rockfish case reflect the benefits of an institutional design in which different organizational disciplines of policy and research contribute independently to a decision process. In a recent review, a scholar of such organizational redundancy remarked, "when means-end relations are uncertain, having multiple minds work independently on the same problem increases the probability of success."[154] This general principle is clearly borne out in the rockfish case.[155]

Reducing the scientific and policy capacity of a system of governance is likely to reduce redundancy. For instance, the research fund that supported the genetic work on rockfish might be cut as part of further pressures on the agency budget, perhaps based on the reasoning that academics or other external parties would undertake similar research at some point in the future. One might see the Department of the Interior's restructuring during the Bill Clinton Administration—which resulted in FWS scientists being reorganized into the United States Geological Survey, thereby depriving FWS of a large research staff—as exactly this kind of reduction of redundancy.[156]

One often sees institutional redundancy as inefficiency: a duplication of effort and resources. However, as this example demonstrates, redundancy can produce greater efficiency in regulation by avoiding Type I and Type II errors. Additionally, this example points to two more general conclusions. First, that research and policy can be redundant in form while being complementary in function. In the rockfish case, NOAA staffs separate offices within the same city (a seeming redundancy), but their complementary natures are clearly evident in the process and outcome of the ESA listing. Second, identifying situations in which redundancy is likely to be constructive can be difficult to do in advance; in the rockfish case, the circumstances led to a result not anticipated by either scientists or policy staff.

The larger point is that reducing redundancy can lower the likelihood of community-wide learning. Within large institutions such as federal agencies, both adaptive management and use-inspired research are vulnerable in this respect. A reduced ability to learn—that is, to adapt and respond to changes in

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Management at the Consultative Group on International Agricultural Research (CGIAR), 113 PROCEEDINGS OF THE NAT'L ACAD. OF SCI. 4615, 4615 (2011) (defining boundary objects as "collaborative products such as reports, models, maps, or standards that 'are both adaptable to different viewpoints and robust enough to maintain identity across them.").

154. Bendor, *supra* note 146, at 200.

155. *Cf.* Nicolás. L. Gutiérrez et al., *Leadership, Social Capital and Incentives Promote Successful Fisheries*, 470 NATURE 386, 386 (2011) (arguing fisheries that are socially resilient tend to be better managed). Under some circumstances a redundant organizational structure should be more socially resilient.

156. The story of the National Biological Survey and its demise has received relatively little attention, but the brief articles on the matter are of significant value. *See generally* H. Ronald Pulliam, *The Political Education of a Biologist: Part I*, 26 WILDLIFE SOC'Y BULL. 199 (1998) (the former director of the Survey capturing his experience in a two-part article); H. Ronald Pulliam, *The Political Education of a Biologist: Part II*, 26 WILDLIFE SOC'Y BULL. 499 (1998); Frederic H. Wagner, *Whatever Happened to the National Biological Survey?* 49 BIOSCIENCE 219 (1999).

the world—can make the system of rules less capable of effective management and can ultimately undermine the system's legitimacy. Yet redundancy is a network effect, resulting from the configuration of organizational units, personnel, and budgets. These networks have not been designed with a view towards advancing learning or protecting redundancy, and the social science knowledge to promote these goals is largely lacking. The rockfish case illustrates the real value of such arrangements, but it is not obvious how to optimize organizational redundancy for learning and adaptation in an ever-changing scientific and political context.[157]

CONCLUSION

The listing of Puget Sound rockfishes stands out as an unusual example of administrative process and science-policy interaction in several respects: (1) critical data were missing on the particular species petitioned for listing, such that the agency could have easily declined to list the species on that basis; (2) instead of so declining, the agency reached for analogous data from other species to fill this data gap; (3) the institutional design of NMFS supported scientific evaluation of the case for listing relatively independently of policy concerns; and (4) as a consequence, genuine scientific inquiry on the part of agency scientists drove the development of new analytical techniques and sophisticated reassessment of the original decision beyond what was strictly legally necessary. Had any one of these elements been missing, the rockfish listing and reassessment would have proceeded differently.

We suggest that this unusual example of agency behavior holds practical lessons for making reasonable decisions in the face of scarce data. In particular, the rockfish listing and our own experience strongly suggest that NMFS's separation between scientific and policy functions plays a positive role in encouraging science-driven policy decisions via community-wide learning. This kind of beneficial institutional redundancy may be generally valuable for federal agencies making decisions under conditions of significant uncertainty (that is to say, all of them), although it remains unclear how to calibrate institutional design to generate net efficiency gains from such redundancy.

As to the ESA and future listing decisions specifically, the question of how to prioritize action on petitioned species is made more challenging by thin agency budgets, competing priorities, and the need to fulfill unfunded mandates. Are better-known species *a priori* more deserving of protection?[158] As a practical matter, how might we make reasonable decisions about species that we know little about? When should we revisit decisions we have made in

157. For further discussion, see Holly Doremus, *CALFED and the Quest for Optimal Institutional Fragmentation*, 12 ENVTL. SCI. & POL'Y 729 (2009).

158. FWS's prioritization scheme for species petitioned to be listed under the ESA ranks species with little or no available data last in line for consideration. *See* Methodology for Prioritizing Status Reviews and Accompanying 12-Month Findings on Petitions for Listing Under the Endangered Species Act, 81 Fed. Reg. 49,248, 49,248–50 (July 27, 2016) (notice).

the recent past? And when, if ever, is it reasonable to delay a decision in the hopes that future technological advances will bring more relevant information to bear on the question at hand? Plainly, there are no easy answers to these questions, but the rockfish case suggests that genuine scientific inquiry from line-level agency staff can yield organic answers to difficult questions in a way that strengthens the agency's claim to responsible management of public resources.