The Indicator Species: Tracking Ecosystem Collapse in Arid California

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"We should be standing on five feet of snow," declared California governor Jerry Brown in April 2015, as he announced the state's first-ever mandatory restrictions on urban water use. The governor was standing on a dry, brown field high in the Sierra Nevada, ninety miles east of Sacramento at Phillips Station, site of the state's annual snowpack survey, which revealed that the water content of the Sierra Nevada snowpack was at its lowest level in recorded history. Four years into a historic drought, the announcement intensified an already growing sense of crisis in California and put a national spotlight on the question of the sustainability of the state's highly engineered system of water provision. The site of Brown's speech was well chosen to provoke such reflection: without Sierra snowmelt, there would be little water to circulate through the massive complex of reservoirs, pumps, canals, and aqueducts that constitute the state's hydrological system—a system that has enabled the arid Central Valley to become the source of one-third of the United States' agricultural produce and Southern California to sustain a still-growing population of over 22 million. Beyond indicating the insufficiency of the coming year's water supply, the snowpack survey was also a portent of the longer-term future. Projections of the impact of climate change on precipitation in the Sierra Nevada indicated that over a fifty-year horizon, the snowpack levels upon which the state's water circulation system depended were likely to decline precipitously.[1]

1. Climate models indicated that future precipitation in the Sierra Nevada would increasingly come in the form of rain rather than snow. The California Climate Adaptation Strategy (2009) estimated that the snowpack would be reduced from its mid-twentieth-century average by 25–40 percent by 2050.

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Declining flows of water from the mountains not only threatened urban and agricultural users to the south. Just two weeks earlier, a less publicized survey was conducted in the region where the Sierra snowmelt flows, the San Francisco Bay-Delta. It held equally grim news. The California Department of Fish and Wildlife's annual Kodiak trawl survey, which measures the abundance and distribution of delta smelt by capturing them as they aggregate to spawn, caught only six of the once abundant, but now endangered, fish. The delta smelt was one of several species, also including the Sacramento River winter-run chinook salmon, the Central Valley steelhead, and the green sturgeon, whose numbers were collapsing despite preservation efforts, as state and federal water project operators continued to divert massive amounts of freshwater from the delta to Central Valley farms and Southern California cities during the drought. For many observers, the decrease in freshwater flows through the delta, due to both drought and diversion, was a key source of the steep decline in native fish populations.

"We need to be planning for delta smelt extinction," commented fisheries biologist Peter Moyle (2015), a longtime observer of fish species native to the delta, "and, perhaps, its resurrection." Moyle's reference to resurrection alluded to a captive population of the fish that was being maintained by the University of California, Davis, with the support of the Federal Bureau of Reclamation, the agency that manages one of the two major projects that pump water from the delta to arid southern regions of the state. According to the bureau, the "genetically managed refugial population" served as a "critical safeguard against species extinction in the event that the natural population continues its decline" (UC Davis 2015). Even if wild smelt ceased to exist in their current delta habitat, the captive population held out the possibility of a future reintroduction in a restored ecosystem.

At one level, the apparent demise of the delta smelt was a relatively minor event in an age of human-caused extinctions (see Kolbert 2014). The species is hardly charismatic: a two- to three-inch-long translucent fish that lives for one year in open water, it is a poor swimmer, survives on phytoplankton, and serves as prey for larger fish (see fig. 1). Had it disappeared a few decades earlier (as another native to the delta, the thicktail chub, did in the 1950s) it might never have become an object of scientific and political interest. And indeed, the delta smelt's extinction was unlikely to be mourned by those whose water supplies were threatened by its precarious position. But this modest creature had nonetheless taken on an iconic status due to its centrality to political and technical debates over water in the state over the prior two decades. Debates over how to deal with dwindling future water supplies were shaped by a long-running legal and regulatory struggle over the relative prioritization of human and nonhuman needs.

Figure 1 The endangered delta smelt. Wikimedia Commons

The smelt's significance had less to do with its intrinsic qualities than with what its disappearance might portend. For advocates of smelt protection, the continued existence of the fish was important beyond the value of preserving a unique species: the fish was an "indicator" of the health of the delta region as a whole—and its apparent demise was a tragic sign of the delta's ongoing ecological collapse. For its detractors, efforts to protect the smelt—which had led to restrictions on state and federal water project diversions—involved an irrational prioritization of fish over people. More broadly, the debate over whether and how to preserve the threatened species pointed to tensions around whether the demands of the human-built systems upon which the state's population depended could be aligned with the norms of the ecological systems they necessarily transform. And as we will see, the projected effects of climate change on future water supplies in California only exacerbated these tensions.

This essay tracks the two-decade-long struggle, conducted by an alliance of fishery biologists, sport fishermen, and environmental advocacy groups, to protect the delta smelt and other native fish populations. Through the case of the smelt, it asks how the goal of species preservation, enshrined in the 1973 Endangered Species Act, is integrated into contemporary governmental practice. What values are at play in efforts to sustain the existence of nonhuman life in a setting of intense competition over a diminishing and essential resource? What forms of knowledge

are developed to gauge the health of threatened species, and what techniques are used to regulate the provision of water in the name of species protection?

The essay suggests that smelt protection efforts are guided by two temporally distinct value orientations. The first is past-oriented, emphasizing the preservation of existing species as a good in itself. This value is at the heart of the legislation that structures species protection efforts in the United States, the Endangered Species Act. The second is future-oriented, focused on staving off an approaching ecological collapse whose onset is signaled by the smelt population's decline. Here the threatened species is not valued for its own sake but rather serves as a proxy in a struggle against a broader catastrophe: it is an indicator of a more general ecological condition. From this latter perspective, the Endangered Species Act provides potentially powerful regulatory tools for limiting or redirecting human incursions into fragile ecological systems, but the impact of such regulation is limited by the act's narrow focus on species protection.

The regulatory methods adopted to redirect water toward nonhuman needs depend upon which of these value orientations is embraced. As the essay will show, while supporters of smelt protection are mainly guided by a desire to stave off the collapse of the delta ecosystem, their capacity to intervene in the water system is constrained by the legal means at their disposal. Endangered species legislation provides them with a powerful tool to counter entrenched economic and political interests, but it demands an emphasis on the preservation of particular species. Due to the smelt's threatened status, water operators have been required to closely monitor its living conditions and calibrate their pumping activities in response. It is not clear, however, whether such regulation has improved the species' long-term prospects and even less whether it has contributed to improving the health of the ecosystem.

The Management of Flows

The Bay-Delta region, which extends westward from the meeting point of the Sacramento and San Joaquin Rivers to the San Francisco Bay, is the West Coast's largest estuary, the source of much of the state's urban and agricultural water, and a refuge for dozens of native species of birds and fish. A century and a half of Euro-American habitation has transformed the region from a tidal marshland of variable salinity and regular flooding into a stable, mostly freshwater lake and river system of dredged channels, earthen levees, small islands, and irrigated farms. Beginning in the second half of the nineteenth century, settlers in the American West drained its marshes, logged its forests, and built dikes to

control flooding and stabilize its course. An extensive but fragile system of canals and levees was constructed in the early twentieth century to make the land more amenable to farming. However, the most significant transformations to the delta took place from the 1930s to the 1960s, as massive federal and state water projects were built to generate hydroelectric power, control seasonal flooding, irrigate the Central Valley, and, later, provide water to consumers in the growing cities of Southern California (see fig. 2). Water circulation through the delta is so carefully managed that it is often described as the state's "plumbing system."

Figure 2 California's water circulation system. Wikimedia Commons

The engineering of California's major water systems is typical of large-scale infrastructure development in the mid-twentieth-century United States. The construction of the Central Valley Project by the New Deal–era Federal Bureau of Reclamation began in the 1930s. The project treated Sierra snowmelt and watershed runoff as a natural resource to be exploited for agricultural production and hydroelectricity and as a flood risk to be managed. The question of whether the diversion of freshwater from the delta might have unintended ecological consequences was not part of the planning calculation. At the intersection of the two major river systems of California, the Sacramento River and the San Joaquin River, the Central Valley Project stores water in reservoirs in the Sierra foothills and releases it in controlled flows through a series of pipes and canals into the delta. From there the water either continues westward through the delta into the San Francisco Bay or is pumped southward along the eastern side of the San Joaquin Valley through multiple canals, aqueducts, and pump plants.

Another major water storage and delivery system, the State Water Project, was built in the 1960s, funded by state water bonds and managed by the California Department of Water Resources. Like the Central Valley Project, it uses massive pumps located in the southern delta to transport water south—in this case, along the western side of the San Joaquin Valley and to the urban agglomerations of Southern California. The nation's largest government-built water system, the

State Water Project includes thirty-four reservoirs, twenty pumping plants, five power plants, and seven hundred miles of canals and pipelines. It supplies water to 750,000 acres of farmland and 25 million residents through water contractors such as the Westlands Water District of central California and the Metropolitan Water District of Southern California.

Following the mid-twentieth-century paradigm of state-based infrastructure development, both projects conceptualized watershed flow as a natural resource to be exploited for the purpose of agricultural and urban development (see Collier and Lakoff 2015). As President John F. Kennedy put it in dedicating a portion of the Central Valley Project in 1963: "The flows of two watersheds can now be regulated for the benefit of the farms and cities of the lower valley." In turn, allowing the water to run through the delta into the sea would be a waste: "For too long, this water ran unused to the sea" (quoted in Shigley 2012). These vast engineering projects were crucial to the growth of the Central Valley agricultural industry and Southern Californian cities in the second half of the twentieth century. Today federal and state project operators continue to supervise the timing and amount of water sent from reservoirs in the mountains into the delta and then from the delta to water contractors and utility agencies in the central and southern parts of the state. Before the current period of water restrictions—due both to environmental regulations and water scarcity—the two water projects diverted an average of 6 million of the delta's 23 million acre-feet of annual freshwater flow.[2]

This model of government-managed resource extraction and circulation via big infrastructure projects came into question in California and elsewhere by the late 1970s, with the rise of the environmental movement and increasing public concern about the unintended ecological consequences of such projects (see Beck 1995). In the case of California water politics, new alliances arose to challenge the technocratic authority of water managers focused on the goals of increased agricultural production and urban growth. The ecological health of the delta was at the center of these struggles, which consolidated in the early 1980s protest of a proposed "peripheral canal" to be built at the eastern end of the delta. The proposed canal was meant to connect the Sacramento River directly to the State Water Project aqueduct to keep saltwater from the San Francisco Bay from intruding into the delta as its freshwater was pumped southward. Initially envisioned as the final element in the State Water Project, the peripheral canal project was challenged both by delta-area farmers and fishermen and by environmentalists who feared that

2. Additional in-stream and upstream diversions amount to approximately 5 million acre-feet per year. The percentage of water diverted becomes much higher during drought years. See Layzer 2008.

siphoning off more water from the Sacramento River would lead to the collapse of the entire delta ecosystem. The defeat of the canal proposal by California voters in 1982 marked a new era in the state's technopolitics, in which major infrastructure projects would face challenges from new and unexpected alliances.

In the ensuing years, tension has only increased between the continually expanding water needs of the arid parts of the state and ever more dire forecasts of the delta's ecological collapse. On the one hand, the federal and state projects have had difficulty meeting contractual obligations to local water districts, especially in drought years. On the other hand, environmental regulations have begun to restrict water operations as populations of native fish species have crashed. It is in this context—of increasing shortfalls in water delivery and intensifying environmental crisis—that the prominence of the delta smelt both as an endangered species in need of protection and as an indicator of impending ecological collapse must be understood.

An Indicator Species

The Endangered Species Act of 1973 has served as the legal basis for smelt protections and, more generally, for efforts to restore the delta habitat so that native fish populations can be sustained. There are three key regulatory steps in endangered species protection, according to the law. First, one of the federal wildlife agencies officially lists the species as threatened or endangered in response to a public request; such a listing prohibits any act that may harm the species or degrade its critical habitat. The second step is the official designation of the species' critical habitat—that area whose protection is deemed crucial to the recovery of the species. The third is the development of a recovery plan, which typically involves a strategy to restore and enhance the species' critical habitat (Benson 2012).

As noted above, efforts to protect the smelt, unlike movements to prevent the extinction of more charismatic fauna such as the red wolf or the desert tortoise, are not driven by an affective connection with the endangered animal. Rather, one finds articulated in discussions of the fate of the smelt a more general sense of endangerment: that the smelt's decline is symptomatic of a broader, unfolding tragedy of ecosystem collapse.[3] It is an event in which humans are implicated both as its cause and as one of the affected species. Thus smelt advocates commonly use the concept of the "indicator species." An indicator, as Theodore M. Porter (2015) notes, is a device used to point to something—such as the economy—that

3. For a historical analysis of the affect of endangerment, see Vidal and Dias 2015.

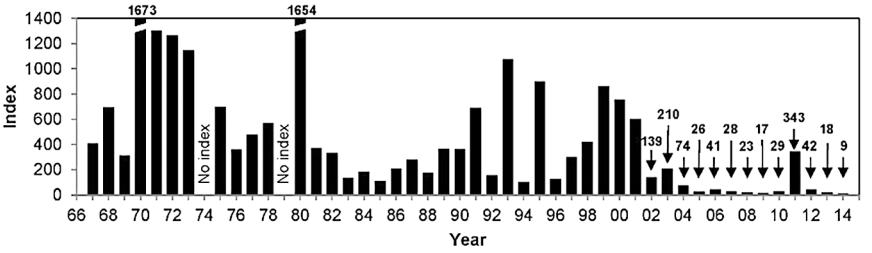

Figure 3 Results of the annual survey of delta smelt abundance. Source: State of California, Department of Fish and Game, memorandum, "Fall Midwater Trawl 2014 Annual Fish Abundance Summary," January 7, 2015

cannot be easily grasped through direct measurement. In place of the thing of interest, the indicator measures something whose movements show a consistent relationship to that thing.

In this case, annual surveys indicating rapid declines in native fish populations such as the smelt point to the possible onset of an event that is difficult to directly perceive or measure: the collapse of an ecosystem (see fig. 3). Here the indicator species function as a sentinel device—alerting us to the approach of an uncertain but catastrophic threat (see Keck and Lakoff 2013).[4] The construction of sentinel devices is designed to spur intensive action to mitigate such threats. In this sense, the sentinel device is part of a precautionary apparatus: an alert that tells us we must take action, even in the face of uncertainty, to avert disaster (Chateauraynaud and Torny 2005). By the time we are certain about the accuracy of the sentinel's warning it will be too late. However, such signals of warning face challenges in spurring intervention. When the stakes of intervention are high—when precautionary measures are costly—the validity of the sentinel's warning, or its relation to an imagined future, is often contested.[5] While a sentinel device makes it possible to perceive the onset of a possible future catastrophe, it does not by itself ward off the impending danger. In the case of the threatened delta ecosystem, this is where the Endangered Species Act proved potentially useful.

4. Historical examples of nonhuman sentinels include the use of lichen distribution to detect air pollution in nineteenth-century Paris and the use of fish to study river pollution in Germany in the early twentieth century.

5. One may think of the role of bee colony collapse in debates over pesticide use or of coral reef degradation in discussions of the effects of climate change. See Keck and Lakoff 2013.

The Smelt as Proxy

The delta smelt, an open-water species endemic to the San Francisco Bay-Delta, was once among the delta's most abundant fish. In the late 1980s, fishery biologists led by Moyle of the University of California, Davis, began to notice a sharp decline in native fish populations, including chinook salmon, steelhead trout, and delta smelt. Based on observations in Suisan Marsh, Moyle estimated that the fish's population had plummeted by 90 percent since the late 1970s. Further evidence of the fish's decline came from the California Department of Fish and Game's Summer Townet Survey, conducted annually since 1959. The survey involves a series of ten-minute-long trawls using a standard-size net to gather fish at thirty-two sampling stations in the delta. Surveyors then enumerate all of the fish caught in these trawls. The survey was initially conducted to understand the impact of the Central Valley Project on striped bass populations (an introduced species) and thus on sportfishing, but smelt and other species were also captured in the trawl and counted.[6] Using archival data from the Townet survey, fisheries biologists developed the "delta smelt index" in 1990, which generated a useful retrospective record of historical changes in smelt abundance. This index would become increasingly significant over the next two decades as a means of tracking the decline in the smelt population and, more generally, in gauging the health of the delta. According to the California Department of Fish and Wildlife (2015), "Delta smelt abundance trend data was used as supporting evidence for their listing as threatened in 1992 under the Federal and State Endangered Species Acts."

On the basis of these findings, sport and commercial fishing associations along with fisheries biologists pressed state and federal wildlife services to list the delta smelt as a threatened species under the Endangered Species Act. The proposal was immediately controversial, as state water managers and local water contractors understood that Endangered Species Act protection of the smelt's habitat—the entire delta—would likely imperil regular water deliveries to the south. For instance, it might be necessary to turn the pumps off when the smelt spawned in the late winter and early spring, typically a period of intensive water diversion. An official from the Metropolitan Water District, which supplied water to 15 million users in Southern California, estimated that pumping restrictions could lead to 25 percent shortages in water availability. To stave off such arrangements, water

6. The California Department of Fish and Wildlife (2015) explains that the Summer Townet Survey "began in response to the development of Central Valley Project pumping plants exporting water from the south Delta. These exports created a need for information regarding distribution of young striped bass relative to the south Delta diversions."

contractors argued that the cause of the smelt's population decline was unclear and requested further study.[7] Meanwhile, environmental activists who saw freshwater exports as destroying the San Francisco Bay and Delta ecosystem advocated an endangered species listing. As a member of the Bay Institute said, "If we can use the delta smelt to document [damage to the delta], we will" (quoted in Morain 1991). Thus even before it was officially listed as threatened, the smelt was a proxy in a larger statewide struggle over water provision.

After several years of analysis and debate, in the spring of 1993 the US Fish and Wildlife Service officially listed the delta smelt as "threatened" under the Endangered Species Act, and California's Department of Fish and Wildlife followed suit shortly thereafter. In 1994 the US Fish and Wildlife Service designated the entire San Francisco Bay-Delta as a "critical habitat" for the smelt, and in 1996, the agency released its recovery plan for delta native fisheries. These were critical steps: the listing of the species as threatened and the designation of its critical habitat meant that any action in any part of the delta that could imperil the lives of smelt was subject to sanction under the Endangered Species Act prohibition of "taking."

In its listing announcement, the Fish and Wildlife Service followed fisheries biologists and environmental activists in claiming that the smelt's significance extended beyond the species itself: its demise "may be indicative of the relative health" of the delta as a whole (Murphy 1993). The sentinel vision was already part of the rationale for preservation efforts. As a biologist with the Fish and Wildlife Service put it, "If that species gets wiped out, it is really saying the delta is going to the dogs" (quoted in ibid.). Similarly, Moyle argued that listing the species as threatened under the Endangered Species Act "tells people the delta system is in serious trouble and needs to be fixed" (quoted in ibid.). He sought to link the species-oriented values embedded in the Endangered Species Act to the problematic of ecosystem health: "The bottom line for me is that we don't have the right to eliminate a species. It is a moral issue, especially when we know keeping it around will mean a healthier ecosystem" (ibid.).

The smelt was able to take on this role of an indicator species due to its particular sensitivity to environmental change. It is dependent for its survival on the characteristics of the ecosystem in which it evolved, such as the brackish zone of low salinity where freshwater inflows meet the Bay's tidal currents, and on the availability of an abundance of phytoplankton in the food web. Smelt do not swim

7. Dick Clemmer, the Metropolitan Water District's manager of Bay-Delta affairs, said in 1991: "We are going to try to influence the decision. We firmly believe there isn't enough information to call for a listing" (quoted in Morain 1991).

well, but tend to ride along the river's currents. If these currents are redirected to deadly pumping stations, the smelt are passively "entrained" in vast numbers. The smelt population's decline was, for ecologically minded observers, intimately linked to long-term damage to its habitat. As the delta was channeled and diked, as its flows were managed and its freshwater diverted, and as it was contaminated with pesticide residue and sewage treatment runoff, it had become more hospitable to invasive plant and animal species and less so to natives like the smelt, whose die-off was the signal of an ecosystem in crisis.

For many activists and environmental scientists, the main source of this crisis was a significant decrease in freshwater flows through the delta, especially in the wake of the State Water Project's completion in the late 1960s. From this perspective, insofar as Endangered Species Act regulations might help restrict freshwater diversion, efforts to protect the smelt held the potential to achieve broader aims of ecological renewal.[8] As the executive director of the Bay Institute put it, "The listing of the delta smelt could be the most important step in restoring the delta" (quoted in Murphy 1993). But there were certain risks to the strategy of tying repair of the delta to the fate of the smelt. For one, endangered species regulations could point toward narrow protection measures rather than toward a more general ecological restoration: for instance, using monitoring techniques near the water projects' pumps to ensure that smelt were not entrained, rather than increasing freshwater flow through the entire system. In addition, a focus on the individual species would allow defenders of ongoing water exports to claim that the central issue was one of "fish versus people" rather than the overall sustainability of the state's hydrological regime. Finally, if the species did become extinct despite preservation efforts, there might no longer be a legal-regulatory basis for limiting water exports.

The Pelagic Organism Decline

The 1993 listing of the delta smelt as a threatened species led to two decades' worth of regulatory negotiation and legal contestation. In a first stage, lasting roughly until 2005, the various governmental entities involved—the Environmental Protection Agency (EPA), the Bureau of Reclamation, the Fish and Wildlife Service, and the California Department of Water Resources, among

8. Melinda Harm Benson (2012) points more generally to the significance of the Endangered Species Act in transforming state and federal water management practices: "The ESA disrupted the trend of resource extraction within these watersheds and forced consideration of the consequences of these activities to the ecological systems at issue."

others—sought to harmonize the seemingly opposed goals of maintaining water deliveries to the south and restoring the delta smelt's habitat. In a second stage, as it became apparent that these initial efforts had failed to stem the decline of native fish populations, a more contentious legal and scientific struggle arose over the grounds for restrictions on water project operations.[9]

The first stage was a period of increasing scientific and regulatory scrutiny of the smelt population's living conditions and the initiation of experiments in managing its well-being. In 1992, in response to long-running concerns about the effects of the water projects on the water quality and ecological health of the delta, Congress passed the Central Valley Project Improvement Act, which required the Federal Bureau of Reclamation to reconfigure its project operations to "protect, restore and enhance" fish and wildlife (Pub. L. No. 102-575, title 34, 106 Stat. 4706 [1992]). This included measures such as allowing increased flows through the delta to improve fish habitat and providing water for wildlife refuges. Soon after, in 1994, a collaborative regulatory arrangement was instituted between state officials protective of water exports and federal regulators attuned to the water projects' environmental consequences. The goal of the arrangement, called the CALFED Bay-Delta Program, was to balance among the various competing interests to provide sufficient freshwater flows to the delta to protect endangered fish populations.

CALFED's objective was not to restore a damaged ecosystem but rather to ensure that urban-agricultural water supplies were not disrupted while providing enough water to meet legal requirements for the fish (Layzer 2008). For our purposes, the arrangement is of interest as a setting in which new techniques and knowledge practices were invented to adjudicate between ecological needs and consumer demands. One of CALFED's innovations was the Environmental Water Account program, which aimed "to facilitate real-time adjustments in water project operations to prevent the deaths of migratory and estuarine species at state and federal water pumps" (Layzer 2008: 137–38). The water account sought to provide water operators with flexibility so that they could slow or shut down the pumps when the smelt were nearby. The water thus "spent" on fish protection would—in principle—be paid back through the environmental water account. However, the account remained underendowed, and so the wildlife agencies were not able to provide enough water to protect the smelt from entrainment in the pumps at the southern edge of the delta.

After a brief period in the late 1990s in which it looked as though native fish

9. For the details of this history, see Alagona 2013.

populations might rebound, there was another crash beginning in 2002, which environmental scientists termed the "pelagic organism decline" (Sommer, Breuer, and Mueller-Solger 2007). The sharpness of the decline in native fish populations was startling to scientists. Following the results of a 2005 survey, EPA fisheries biologist Bruce Herbold said: "I'm not much of an alarmist, but I'm starting to look at it that way. I'm starting to look at it as the sky is falling" (quoted in Taugher 2005). Numerous native species showed steep drop-offs in surveyed populations. Herbold reflected on the significance of declining numbers of threadfin shad, a previously common baitfish: "To have it going from really abundant to scarce, it's scary. Something is really, really wrong. It is not just the sensitive fish. The cockroaches are dying off" (ibid.). The slow, steady practice of trawling for native fish, year after year, had now generated a piercing alarm.

The delta smelt population, tracked carefully due to its threatened status, was measured in 2005 at its lowest level ever. As historian Peter S. Alagona (2013: 216) notes, the smelt's decline came to stand in for the delta's "slow-motion ecological collapse." According to Herbold, the EPA scientist, either delta conditions had now degraded past a "pivot point" and were in a state of general collapse or some other unknown factor had changed (quoted in Taugher 2005). A biologist from the California Department of Fish and Game indicated scientists' uncertainty about the cause of the rapid and sudden decline. "We're going to put everything on the table, from toxics to water operations to [invasive] species to even toxic algae," he said. "Everyone is pretty clear in that there's something going on out there. The only question is what it is and what is going to be done about it" (quoted in ibid.). Many scientists continued to suspect that the state and federal water projects' increasing diversions of freshwater from the delta were playing a large part.

Reasonable and Prudent Alternatives

At this moment of perceived crisis, the legal-regulatory regime governing management of the delta's water shifted. Here it is necessary to briefly describe the provisions of section 7 of the Endangered Species Act, which regulates federal agency actions that may affect a listed species. Section 7 requires any agency that plans such an action to consult in advance with one of the wildlife agencies. In turn, the wildlife agency generates a "biological opinion," which determines whether the proposed action is likely either to "jeopardize the continued existence of the species" or to result in "destruction or adverse modification" of the species' critical habit. If so, the biological opinion then seeks to identify a set of "reasonable and prudent alternatives" that can mitigate the threat to the species and at the

same time allow the action agency to go ahead with its proposed activity (US Fish and Wildlife Service and National Marine Fisheries Service 1998: xi, xvii). It is in the details of these alternatives—which function as regulations—that the goal of species preservation is integrated into the techno-administrative procedures of resource management. As we will see, the biological opinion is the crucial document in the legal determination of how water-pumping operations must be managed in order to protect a threatened species.

In 2004, as part of the CALFED process, the Federal Bureau of Reclamation released a proposed operational plan for its coordinated Central Valley Project and State Water Project water management activities. A year later, the Fish and Wildlife Service issued its biological opinion on the bureau's plan, which concluded that the bureau's ongoing pumping activities would have no adverse effect on the recovery of the delta smelt or on its critical habitat. Diversion could go forth as planned.

In response, the Natural Resources Defense Council filed suit in federal court, challenging the biological opinion as "arbitrary and capricious" (Alagona 2013: 218). The case was assigned to the federal district court in Fresno, presided over by Judge Oliver Wanger, a conservative appointee of President George H. W. Bush. Two years later, in December 2007, the judge issued what became known as the "Wanger decision," which would become an ongoing source of consternation among water contractors in California. Wanger ruled that the project operators' pumping activities posed an unacceptable risk to the survival of the delta smelt. He grounded this decision on his understanding that the Endangered Species Act mandated the prioritization of listed species over any other competing interests.

Wanger ordered the water projects to reduce their pumping operations to avoid entraining smelt in their pumps at the southern end of the delta. Specifically, he required project operators to lower the speed at which the water projects were reversing the flow of the rivers and thereby dragging smelt into their pumping machinery (San Luis & Delta-Mendota Water Authority v. Jewell [9th Cir. 2014]: 62). For environmentalists, the ruling demonstrated the potential of using the Endangered Species Act to pursue broad aims such as habitat conservation and stream-flow restoration, whereas for the water contractors, it came as an unpleasant surprise: a small group of fisheries biologists and environmental lawyers had managed to alter the schedule of pumping activity that supplied water to over 20 million people and millions of acres of farmland (Alagona 2013). From this latter perspective, an obscure, two-inch-long fish now threatened the future reliability of the state's water supply.

Wanger also ordered the Fish and Wildlife Service to generate a revised biological opinion. The new document, released in December 2008, was over four hundred pages long and was the most complex biological opinion the agency had ever produced. It was also the most controversial. In it, the Fish and Wildlife Service reversed its prior assessment: the revised opinion found that the state and federal water projects' planned pumping operations were "likely to jeopardize the continued existence of the delta smelt" and "to adversely modify delta smelt critical habitat" (US Department of the Interior 2008: 276, 277). According to the document, the increase in water diversions due to pumping operations had led to entrainment of the smelt, reduced its habitat, and altered outflows to the delta, changing the location of the zone of low salinity in which the fish tend to live. Moreover, delta smelt were now at their lowest level of abundance since monitoring began in 1967. To recover, according to the document, the smelt would need an increased habitat and a reduction of pollutants, invasive species, and entrainment by the water project's pumps.

The biological opinion then listed the "reasonable and prudent alternatives" the Bureau of Reclamation would have to undertake for its proposed pumping operations to be approved. These regulations were notable for the careful attention to the living conditions of the smelt that would be required of project operators. For example, operators would be required to track the physical proximity of smelt to the huge pumps in the south delta that were blamed for significant fish mortality, as measured by the "daily salvage index." If the salvage index reached a certain threshold, operators would have to reduce diversions for two weeks to limit the reverse flow toward the pumps. Another example concerned the flow of freshwater through the delta out into San Francisco Bay: based on computerized models of smelt behavior, the biological opinion required project operators to adjust the rate of freshwater flows to maintain "X2," the zone of ideal salinity for young smelt, in a part of the delta that increased the smelt's suitable habitat. Thus operators would be required to engage in close supervision of several aspects of smelt existence and regulate water flows in response to these cues. The state's hydrological system would have to be adjusted in near real time in relation to the smelt's movements and to the drift of its brackish habitat.

State water managers estimated that the resulting pumping restrictions would reduce water project deliveries by 20–30 percent and challenged the scientific basis of the biological opinion (Boxall 2008). The director of the California Water Resources Board argued that the federal regulations placed too much blame for smelt decline on the water projects' pumps, noting that chemical contamination,

invasive species, power plant operations, and drought conditions were all harming the delta.[10] Meanwhile, over the course of the following year, a national media campaign led by Central Valley agricultural interests attacked the federal government for its prioritization of fish over people. Farmers held public rallies to denounce the "federally mandated drought." Fox News host Sean Hannity, in his enthusiastic coverage of the protests, told his audience that the Obama administration's Interior Department had decided that "the farmers come second and the delta smelt comes first" (Hannity 2009).

Southern California and Central Valley water districts joined in legal action seeking to overturn the regulations contained in the revised biological opinion. The case again came before Wanger's court. In his December 2010 decision, the judge reversed his prior position, writing that the revised biological opinion was "arbitrary, capricious and unlawful." The decision focused on several technical areas in which, the judge argued, the Fish and Wildlife Service had not used "the best available science" as required in determining reasonable and prudent alternatives (US District Court for the Eastern District of California. 2010. *The Consolidated Delta Smelt Cases*, 225, 219). For instance, he pointed to problems in the wildlife service's method for using smelt mortality rates to limit the allowable rate of reverse river flow: required limits were based on increases in the number of smelt salvaged, but these numbers were not adjusted in relation to the overall smelt population. Wanger also criticized the service's use of two different modeling techniques to determine the optimal location of X2, the ideal habitat for young smelt: the models had not been calibrated, he argued, introducing significant bias to the analysis (ibid., 125). The judge justified his close scrutiny of the service's technical practices through reference to the high stakes of the biological opinion. As he wrote, "The practical result of the X2 Action is to allow large volumes of Project water to escape into the ocean" (Uhlman 2011). This reference to the "escape" of water assumed the hydrological engineers' view of the delta's freshwater as a resource that had been captured by engineers for the public benefit and that must be exploited for human use. From the perspective of ecosystem advocates, of course, water flowing through the delta to the ocean was not a resource being wasted but rather a critical ingredient of the estuary's health.

In later comments, Wanger lambasted the government scientists who had testified in the case as "deceitful zealots." He was especially incensed by the

10. In a *San Francisco Chronicle* op-ed, two attorneys for Central Valley water districts made a similar argument: "Myriad factors negatively affect the well-being of the delta smelt. These include, but are not limited to, a low food supply, presence of predatory fish and a toxic water habitat for the smelt" (Manson and Middleton 2009).

testimony of a Fish and Wildlife Service scientist on the need to increase freshwater outflows to maintain the ideal salinity zone (X2) for young smelt in a specific part of the delta: "The suggestion by Dr. [Jennifer M.] Norris that the failure to implement X2 at 74 kilometers [east of the Golden Gate Bridge], that that's going to end the delta smelt existence on the face of our planet is false. It is outrageous" (quoted in Barringer 2011). Meanwhile, the judge criticized the Fish and Wildlife Service for its failure to do cost-benefit analysis—to weigh the requirements for protecting a threatened species of fish against the resource demands of humans. In its biological opinion, he argued, the agency had "shown no inclination to fully and honestly address water supply needs beyond the species," even as it "interdict[ed] the water supply for domestic human consumption and agricultural use for over twenty million people who depend on the projects for their water supply" (Bailey 2014). In contrast to his earlier opinion, the judge was now unwilling to defend the antiutilitarian principles embodied in the Endangered Species Act.

The legal back-and-forth continued for several more years, as environmental groups appealed the 2010 ruling to a higher court. In March 2014, the Ninth Circuit Court of Appeals reversed Wanger's decision by a 2–1 verdict, upholding the earlier findings of the Fish and Wildlife Service in its revised biological opinion. The appellate court argued that the wildlife agency should be given considerable deference in evaluating its use and interpretation of scientific evidence and faulted Wanger for attempting to intervene in the scientific discussion by staging a "battle of the experts" (San Luis v. Jewell, US Court of Appeals, 9th Circuit, March 13, 2014 at 47). The judiciary, in other words, should not be a "forum for debating the merits" of the biological opinion (ibid. at 48).

Meanwhile, the appellate majority defended the wildlife service's technical practices in generating its list of reasonable and prudent alternatives. On the question of whether rates of smelt mortality as detected by salvage screens could be used to regulate water flows, the court acknowledged the high stakes of the question: limiting the rate of the rivers' reverse flow "has great practical significance . . . as it represents the ultimate limit on the amount of water available to sustain California's millions of urban and agricultural users." But the court held that the wildlife service "did not act arbitrarily or capriciously in choosing an analytical tool that resulted in greater protections for the imperiled smelt population" (ibid. at 62). And with respect to the service's method for determining the optimal location for the low salinity zone where young smelt congregate (X2), the court outlined the significance of the issue: "Because the location of X2 directly affects how much water can be exported to southern California for agricultural and domestic purposes, the determination of where X2 is located was critical to the parties"

(ibid. at 75). But, again ceding authority to the Fish and Wildlife Service, the majority decision emphasized that it was up to the agency's reasoned judgment to decide on the appropriate method for making this determination.

Finally, the court strongly disagreed with Wanger's admonition that the wildlife service should have weighed the benefits of smelt protection measures against the costs such measures imposed on human water users. Alluding to a 1977 Supreme Court decision concerning the endangered snail darter, the court wrote: "The law prohibits us from making 'such fine utilitarian calculations' to balance the smelt's interests against the interests of the citizens of California" (quoted in Bailey 2014).[11] According to the Endangered Species Act, the value of the existence of a species was "incalculable" and so could not be brought into relation with economic costs. Thus "the FWS [Fish and Wildlife Service] is not responsible for balancing the life of the delta smelt against the impact of restrictions on CVP/SWP [Central Valley Project / and State Water Project] operations" (San Luis v. Jewell at 117). Rather, the duty of the agency, the court argued, quoting the 1977 Supreme Court opinion, is to "halt and reverse the trend toward species extinction, *whatever the cost*" (ibid. at 117).

The following year, the US Supreme Court declined to hear the water agencies' appeal of the Ninth Circuit Court's judgment. At last, it seemed that the legal wrangling over the 2008 biological opinion had come to an end. While advocates of smelt protection could take heart at the support the fish had received from the courts, their judicial triumph was dampened by the data coming in from native fish population surveys in the delta. Over the intervening years, especially given the dire drought in California, restrictions on pumping prescribed by the 2008 biological opinion had not significantly increased freshwater flow into the delta—indeed, in 2014 and 2015 these restrictions were waived in response to the drought emergency. The many possible factors leading to native fish decline remained pervasive: alongside a lack of freshwater flow and entrainment at the pumps, there were other factors, such as invasive species, pesticide residues and sewage runoff, and an interrupted food web. The Endangered Species Act listing process as a tool for intervening in human practices in the name of species survival was limited in the kinds of questions it could pose: How to prevent the entrainment of adult fish?

11. The quotation in the opinion comes from the 1977 US Supreme Court majority opinion in *Tennessee Valley Authority v. Hill*, in which the preservation of an obscure fish—the snail darter—threatened to derail a costly dam project: "[Although] the burden on the public through the loss of millions of unrecoverable dollars would [seem to] greatly outweigh the loss of the snail darter . . . neither the Endangered Species Act nor Article III of the Constitution provides federal courts with authority to make such fine utilitarian calculations" (437 US 153 [1978] at 187).

Where should the brackish, low salinity zone be located? It could not address the warning carried by the smelt as sentinel of ecological collapse: that without a more significant transformation in the state's hydrological system, the delta would cease to function as a habitat for its native species, and the only remaining refuge for the smelt population would be in the Bureau of Reclamation–funded Fish Conservation and Culture Laboratory.

Coda: Infrastructural Transformation and Climate Uncertainty

As smelt protections began to impede water deliveries in the years after 2007, state resource managers and major water contractors sought a way to stabilize flows to urban and agricultural users. One approach was to bypass the problems of the delta and its pumps, to link the mountain snowmelt and watershed runoff from the Sacramento River directly to the aqueducts to the south. It was a solution that had been proposed—and rejected—twenty-five years earlier with the peripheral canal. This time, however, the water conveyors were able to negotiate a provisional settlement with a number of environmental groups.

The resulting proposal, known as the Bay Delta Conservation Plan, was to construct two thirty-mile-long and forty-foot-wide tunnels to carry the Sacramento River's water beneath the delta, at an estimated cost of $25 billion. This massive infrastructural transformation would not actually ship more water to the south, but it would deliver water more reliably, over a time horizon of fifty years. The key to ensuring reliable deliveries was that, if the plan were adopted, project operators would no longer be subject to lawsuits on the grounds of section 7 of the Endangered Species Act. Instead, the modified conveyance system would now be regulated according to a 1982 amendment to the Endangered Species Act, section 10, which emphasized habitat restoration rather than the absolute protection of particular species. Section 10 required water managers to develop a habitat conservation plan in collaboration with the Fish and Wildlife Service and environmental scientists. If a plan could be agreed upon that promised to restore the habitat of threatened species, project operators would be exempted from the section 7 prohibition on "taking" environmental species.[12]

The initial proposal thus comprised two parts: the construction of the two massive tunnels under the delta, alongside a plan to restore one hundred thousand acres

12. The hope, as one board member of the Metropolitan Water District put it, was that the tunnels could "make the Wanger decision inoperable because there won't be as much reverse flow just because you're pulling from north Delta and maybe the rivers will be flowing more naturally and therefore that decision might fall off the face of the earth" (quoted in Maven 2015b).

of delta habitat. This latter piece of the plan helped it gain support from a number of environmental groups, as well as from environmental scientists committed to restoration of the delta. Critical to the proposed plan's success in garnering support from both water resource managers and environmental advocacy groups was the premise that over the fifty-year planning horizon, habitat restoration would be under way and, meanwhile, the water operators would be able to deliver a predictable amount of water to contractors in the central and southern parts of California.

But in the fall of 2014, the plan began to fall apart as wildlife agency administrators and environmental scientists scrutinized the Bay Delta Conservation Plan's environmental impact report. A critical issue involved the plan's claims to be able to model the successful future results of its habitat restoration efforts. Scientists argued that, given uncertainties over what climate change would do to the Sierra snowpack, the salinity levels of the delta, and the capacity of certain species to survive in altered circumstances, it was impossible to project the results of habitat restoration fifty years ahead. On these grounds, federal regulators refused to grant a section 10 permit to the State Water Resources Board.[13] The compromise with environmental groups broke down, since there was no longer a regulatory rationale for water contractors to support large-scale habitat restoration efforts. In an age of mounting climate uncertainty, the planning horizon of infrastructure managers could not be aligned with the modeled future of threatened species.

Moyle, the fisheries biologist who initially recognized the threat to delta smelt existence posed by water diversion, once pointed out that the smelt was "extraordinarily well-adapted for the system the way it was" and, for that very reason, was unable to adjust to the massive transformations the delta had undergone (quoted in Boxall 2011). In parallel fashion, we might say that the federal and state water projects were designed for a mid-twentieth-century climate, in which snow accumulated in the mountains over the winter and could then be stored, as it melted in the spring, for the dry summer ahead.[14] As the breakdown of the Bay Delta Conservation Plan indicated, it would likely prove difficult to adjust this fixed system of water circulation to a rapidly changing climate.

13. As the general manager of the Metropolitan Water District reported to a meeting of the district's special committee on the Bay-Delta: "The conversations we've had with Cal Fish & Wildlife is that their concern really has to do with scientific uncertainty. The idea that we would be projecting how everything would be operating 50 years from now has just widened the uncertainty to such a range that they believe the modeling and the documents doesn't lead to a functional permit at that point" (quoted in Maven 2015a).

14. "The whole water system that we have in California was designed for the old climate," as one climate scientist put it. "The water system wasn't built for the climate that we have now" (quoted in Gillis 2015).

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