ECOLOGY

Hatching a Mongrel Species

Jared Farmer

An Entirely Synthetic Fish
How Rainbow Trout Beguiled America and Overran the World

by Anders Halverson

Yale University Press, New Haven, CT, 2010. 279 pp. $26, £20. ISBN 9780300140873.

Rainbow trout (*1*) used to be a Pacific Rim fish. In historic times, the numerous discrete populations from Baja California to the Kamchatka Peninsula could be grouped into two ecological types, stream trout and anadromous trout (which migrate from the sea to freshwater to spawn). In America, the latter populations became known as steelhead. Starting in the late 19th century, Americans added a third type, hatchery trout. Like the original rainbows, these fish could travel long distances to spawn, but they expended no energy of their own to do so. Instead, people served as their vector, transporting them in trains, trucks, airplanes, and milk cans. Today, rainbow trout can be found on every continent and in every climate; it is the most ubiquitous stocked game fish on Earth. These planned introductions, like all things human, have produced unplanned consequences.

Rainbow trout.

According to Anders Halverson, almost all hatchery rainbows share some ancestry in a Northern California broodstock from the McCloud River—now an arm of Shasta Lake. There, in the 1870s, the U.S. Fish Commission established a hatchery, initially for Pacific salmon. Conservationists back East wanted to import western fish to restock streams degraded by agriculture, logging, and industry. After the failure of Pacific salmon introductions, the station experimented with rainbow trout (a congener). Agents placed fertilized eggs between layers of wet moss in boxes with ice blocks and shipped them by transcontinental railroad.

Rainbows became successful invaders for three main reasons: they make good game; they can tolerate warmer and siltier waters than can other game fish; and they grow well in hatcheries. In the 19th century, the species appealed to acclimatization societies (who wanted to increase what we now call species richness) and river renovationists (who shared the goals, if not the techniques, of later restorationists). Eastern anglers, predominantly elite white males, also wanted to encourage sport fishing as a way of promoting "American" values and manliness. Rainbows had a Goldilocks effect on fly fishermen, notes Halverson. European brown trout were too hard to catch, eastern brook trout too easy. Rainbows were "just right." After biting easily at the surface, they fought the reel with aerial displays.

In the 20th century, a governmental apparatus grew up alongside trout stocking. The state-level hatchery system in the United States can be compared to its local highway system, in which taxes on gasoline funded road construction, which encouraged more fuel consumption. Similarly, state hatcheries were funded from fishing licenses and a special sales tax on fishing equipment. The more people fished, the more money there was for making fish. Hatcheries became popular fixtures throughout the West. Halverson quotes an official from Washington state who courted controversy when he proposed closing more than one hatchery—what you get if "you cross a sacred cow with a military base."

Until recently, hatcheries cared more about self-perpetuation and customer satisfaction than science. Their measure of success was the "return to creel"—the number of fish taken home by anglers. To increase the return, fish and game departments got in the habit of announcing the dates and times of rainbow releases. Thus, in the span of a few hours, a fish might travel the full circuit from hatchery pond to delivery truck to open water to outdoor grill. In 1949, California pioneered the use of surplus military aircraft to aerially stock alpine lakes with rainbow, brook, and golden trout. This kind of biological bombing is still practiced throughout the West. Thankfully, state officials no longer eradicate native fish using chemicals such as rotenone. Alverson chronicles one egregious episode from 1962 when Utah and Wyoming poisoned the entire upper watershed of the Green River (some 15,000 square miles), creating a clean slate to be filled with trout. They called it "rehabilitation."

Before environmentalists made an issue of rainbows, Trout Unlimited complained about annual stocking. The group had no beef with non-native fish; it just wanted "wild" rainbows rather than the latest hatchery product. As Halverson explains, much of the restocking was in fact a waste. Bureaucrats assumed that streams needed to be replenished each year, and they had the budget to do that, so they did. A contrarian fish biologist employed by the state of Montana demonstrated through electroshock censuses in the 1960s and 1970s that the maintenance of population levels came not from restocking per se, but

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from attrition caused by the contest between resident and incoming trout. After some wild public hearings, Montana conceded to science, stopped stocking its rivers, and focused instead on reservoirs where rainbows could not reproduce. Montana has since developed a healthy tourist economy around the quality of its catch-and-release river fishing rather than its gross creel rate.

Colorado did things differently. It stuck by its hatcheries even after their rainbows became infected with whirling disease. The Centennial State now stocks a new rainbow hybrid that is disease-resistant. The hope is that the hybrid will pass on its resistance to rainbows in the wild. Meanwhile, Colorado's greenback cutthroat swims in dangerous waters. The greenback is one of numerous subspecies of cutthroat trout native to the interior West, island populations left from wetter geologic periods. Several of the cutthroats, including the greenback, are federally listed as threatened. The legality of this is debatable, because it is hard to define what the species is anymore. DNA testing has shown that nearly every cutthroat population has to some degree hybridized with rainbows. In Halverson's words, "Rainbow genes have become their own entity." He repeats a 1988 warning from cutthroat experts that the trout of the North American West could homogenize into a single taxon, "*Salmo ubiquiti*" (*2*).

In the wake of environmentalism and conservation biology, some agencies (notably the U.S. Fish and Wildlife Service and the California Department of Fish and Game) have tried to ameliorate the damage caused by trout introductions. In the high Sierra Nevada, native amphibians, especially frogs, cannot coexist with non-native fish. Paradoxically, California still stocks many Sierran lakes, and advertises their locations, even as it actively removes all fish from other nondisclosed lakes. Fishers legitimately question whether it is fair to apply their user fees and tax dollars toward the eradication of their favorite catch.

Halverson, an avid angler, seems well equipped to tackle his topic: he has a Ph.D. in aquatic ecology and experience in journalism. What he lacks is training in history, and that shows. Broad-scale cultural, political, and economic developments get shallow treatment. Halverson prefers to use biographical figures to propel his narrative. It is surprising, then, that he writes so little about the pervasive stocking done by private citizens—characters such as Finis Mitchell, the Wyoming man who almost single-handedly stocked hundreds of fishless lakes in the Wind River Mountains (*3*). In spite of the book's subtitle, which promises a discussion of the rainbow's global diaspora (including self-sustaining populations in New Zealand and South Africa), Halverson rarely ventures outside the United States. The author is mainly concerned with the impacts of hatchery rainbows on fisheries in the inland West. He merely nods to the issue of genetically modified farmed trout. Chile, the world's leader in rainbow aquaculture, appears nowhere in the text.

Halverson works best in his journalistic mode when he travels to western alpine watersheds to interact with "fish squeezers," wardens, and ichthyologists. Through trips and interviews, Halverson entertainingly introduces some of the most tangled questions in conservation biology: What is a species? What is native? What is natural? What is wild? His account does not pretend to be a source for definitive answers or theoretical contexts. For a deeper discussion of many of the same issues, the curious can seek out several recent books on Pacific salmon (*4*–*7*). But for casual readers, including undergraduates and trout enthusiasts, *An Entirely Synthetic Fish* may have gotten it "just right"—sciency enough, not too scientific.

References and Notes

1. Scientific names of taxa mentioned in the text: rainbow and steelhead trout, *Oncorhynchus mykiss* (formerly *Salmo mykiss*); golden trout, *O. m. aguabonita*; Pacific salmon, collectively, six species (chum, *O. keta*; pink, *O. gorbuscha*; sockeye, *O. nerka*; chinook, *O. tshawytscha*; coho, *O. kisutch*; and masu, *O. masou*); cutthroat trout, *O. clarkii*; greenback cutthroat, *O. c. stomias*; brown trout, *Salmo trutta*; brook trout, *Salvelinus fontinalis*.
2. W. Allendorf, R. F. Leary, *Conserv. Biol.* **2**, 170 (1988).
3. J. Nichols, in *Preserving Western History*, A. Gulliford, Ed. (Univ. New Mexico Press, Albuquerque, 2005), pp. 263–271.
4. J. E. Taylor, *Making Salmon: An Environmental History of the Northwest Fisheries Crisis* (Univ. Washington Press, Seattle, 1999).
5. J. Lichatowich, *Salmon Without Rivers: A History of the Pacific Salmon Crisis* (Island, Washington, DC, 1999).
6. R. Scarece, *Fishy Business: Salmon, Biology, and the Social Construction of Nature* (Temple Univ. Press, Philadelphia, 1999).
7. T. P. Quinn, *The Behavior and Ecology of Pacific Salmon and Trout* (Univ. Washington Press, Seattle, 2005).

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BROWSINGS

Oceanic Anglerfishes: Extraordinary Diversity in the Deep Sea. Theodore W. Pietsch. University of California Press, Berkeley, 2009. 569 pp. $85, £59. ISBN 9780520255425.

The cold, dark, nutrient-poor ocean waters below 1 km are home to a surprisingly abundant and diverse clade of anglerfish, the ceratioids. These bizarre predators use a bacterial light organ on the tip of their first dorsal spine to lure prey within reach of their gaping mouth of raptorial teeth. They are also extremely sexually dimorphic; males attach themselves (sometimes permanently) to the much larger, bloblike bodies of females. After detailing "seadevil" diversity, evolution, and distribution, Pietsch discusses bioluminescence, locomotion, feeding, and reproduction. He then comprehensively reviews the suborder's families, genera, and 160 known species (such as *Himantolophus appelii*, left). Although written for fish biologists, this profusely illustrated account should inspire wider interest in these fascinating hobgoblin fish.

Fishes of the Open Ocean: A Natural History and Illustrated Guide. Julian Pepperell; illustrated by Guy Harvey. University of New South Wales Press, Sydney, Australia, 2009. 272 pp. A$54.50. ISBN 9780868407005. University of Chicago Press, Chicago, 2010. $35, £22.50. ISBN 9780226655390.

Relatively few fish species are found in surface waters (down to 200 m) far from land. But these include the largest, swiftest, most prolific, and farthest migrating fish. Some are permanent residents, some spend part of their life cycles at sea, and others are only occasional visitors. Pepperell begins with short discussions of food webs, morphologic adaptations that have independently evolved in several groups, and the impacts of commercial and sports fisheries. The remainder of the book summarizes the identification, distribution, and biology of all major open ocean species, including billfish, tuna, mackerels, jacks, and pelagic sharks and rays. Harvey has painted each species; many are also presented in informative underwater photographs (right, yellowfin tuna, *Thunnus albacares*, prowling the surface).

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