POLICY FORUM

ECOLOGY

Hatcheries and Endangered Salmon

Ransom A. Myers,[1] Simon A. Levin,[2] Russell Lande,[3]
Frances C. James,[4] William W. Murdoch,[5] Robert T. Paine[6]

The role of hatcheries in restoring threatened and endangered populations of salmon to sustainable levels is one of the most controversial issues in applied ecology (*1*). The central issue has been whether such hatcheries can work, or whether, instead, they may actually harm wild populations (*2*, *3*). A new and overriding issue, however, has arisen because of a recent judicial decision.

On 10 September 2001, U.S. District Court Judge Michael Hogan revoked the listing, by the National Marine Fisheries Service (NMFS), of all Oregon coast coho salmon under the Endangered Species Act (*4*). He ruled that, if hatchery fish were included in the same distinct population segment as the wild fish with which they are genetically associated, then they must be listed together. This approach could have devastating consequences: Wild salmon could decline or go extinct while only hatchery fish persist. Petitions are now pending to delist 15 other evolutionarily significant units (ESUs) (*5*).

An ESU is defined as a genetically distinct segment of a species, with an evolutionary history and future largely separate from other ESUs (*6*). For taxonomic purposes, one could use genetic similarity to classify hatchery fish as part of the ESU from which they were derived. However, for assessing ESU extinction risk and/or potential listing under the Endangered Species Act, including hatchery fish in an ESU confounds risk of extinction in the wild with ease of captive propagation and ignores important biological differences between wild and hatchery fish.

We define "hatchery fish" as fish fertilized and/or grown artificially in a production or conservation hatchery. Inevitably, hatchery brood stock show domestication effects, genetic adaptations to hatchery environments that are generally maladaptive in the wild. Hatchery fish usually have poor survival in the wild and altered morphology, migration, and feeding behavior (*7*). On release, hatchery fish, which are typically larger, compete with wild fish (*1*). Their high local abundance may mask habitat degradation, enhance predator populations, and allow fishery exploitation to increase, with concomitant mortality of wild fish (*1*, *8*). The absence of imprinting to the natal stream leads to greater straying rates, and that spreads genes not adapted locally (*1*). Also, hybrids have poor viability, which may take two generations to be detected (*9*).

Interagency draft criteria (*10*) describe hatchery fish most appropriate for inclusion in an ESU as those founded within two generations or those that had regular infusions of fish from the wild population. However, fish grown in hatcheries for even two generations may not assist population recovery; their rate of survival in the wild is much lower than that of wild fish (*11*). Regularly infusing hatchery stocks with natural fish may also be a drain on the natural system. Hence, even these hatchery fish should not be included in an ESU, even if they are indistinguishable at the quasi-neutral molecular genetic loci typically used to identify an ESU.

Much evidence exists that hatcheries cannot maintain wild salmon populations indefinitely (*7*). In the inner Bay of Fundy in Eastern Canada, hatchery supplementation of Atlantic salmon occurred for more than a century (*12*). Despite the longevity of this program, it failed to maintain viable natural populations. Hatcheries effectively disguised long-term problems, which probably contributed to the near extirpation of native Atlantic salmon. Moreover, as recommended by the World Conservation Union (IUCN), long-term reliance on artificial propagation is imprudent, because of the impossibility of its maintenance in perpetuity (*13*).

Although their effectiveness has not been shown (*14*), conservation hatcheries may play a role in future salmon recovery. However, to avoid the dysgenic effects of domestication, even conservation hatcheries should be strictly temporary and should not prevent protection of wild populations under the Endangered Species Act.

To address one of the subsidiary lawsuits, NMFS has pledged to complete a review of eight ESUs by 31 March 2004. NMFS should continue to pursue its current recovery goal of establishing self-sustaining, naturally spawning populations. The danger of including hatchery fish as part of any ESU is that it opens the legal door to the possibility of maintaining a stock solely through hatcheries. However, hatcheries generally reduce current fitness and inhibit future adaptation of natural populations. Hence, the legal definition of an ESU must be unambiguous and must reinforce what is known biologically. Hatchery fish should not be included as part of an ESU.

[1]Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1; ransom.myers@dal.ca. [2]Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544, USA; slevin@princeton.edu. [3]Department of Biology, University of California–San Diego, La Jolla, CA 92093, USA; rlande@ucsd.edu. [4]Department of Biological Science, Florida State University, Tallahassee, FL 32306, USA; james@bio.fsu.edu. [5]Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara, CA 93106, USA; murdoch@lifesci.ucsb.edu. [6]Department of Biology, University of Washington, Seattle, WA 98195, USA; painert@u.washington.edu

References and Notes

1. National Research Council, *Upstream: Salmon and Society in the Pacific Northwest* (National Academy Press, Washington, DC, 1996).
2. R. Hilborn, J. Winton, *Can. J. Fish. Aquat. Sci.* **50**, 2043 (1993).
3. R. S. Waples, *Fisheries* **24**, 12 (February 1999).
4. *Alsea Valley Alliance* v. *Evans*, 161 F. Supp. 2d 1154 (D. Or. 2001).
5. R. Lent, *Fed. Regist.* **67**, 6215 (2002)
6. R. S. Waples, *Mar. Fish. Rev.* **53**, 11 (3: 1991).
7. S. Einum, I. A. Fleming, *Nordic J. Freshw. Res.* **75**, 56 (2001).
8. J. Lichatowich, *Salmon Without Rivers* (Island Press, Washington, DC, 1999).
9. P. McGinnity *et al.*, *Proc. R. Soc. London Ser. B* **270**, 2443 (2003).
10. NMFS, 2003, www.nwfsc.noaa.gov/trt/brt/backintro.pdf
11. R. Reisenbichler, G. Brown, in "Assessing Extinctions Risk for West Coast Salmon," A. D. MacCall, T. C. Wainwright, Eds. (NOAA Tech. Memo, NMFS-NWFSC-556, U.S. Department of Commerce, Washington, DC, 2003), pp. 147–154.
12. A. J. F. Gibson, J. Bryan, P. G. Amiro, *Can. Data Rep. Fish. Aquat. Sci.* (no. 1123), 2003.
13. IUCN, 2002, www.iucn.org/themes/ssc/pubs/policy/exsituen.htm.
14. F. Allendorf, R. S. Waples, in *Conservation Genetics: Case Histories from Nature*, J. C. Avise, J. L. Hamrick, Eds. (Chapman & Hall, New York, 1996), pp. 238–280.
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