Transgenic Fish: A Boon or Threat?

ERIK STOKSTAD'S ARTICLE "ENGINEERED FISH: friend or foe of the environment?" (News Focus, 13 Sept., p. 1797) entertains the premise that the culture of transgenic fish, which grow two to six times faster than conventional fish, "might alleviate pressure on wild stocks." Two key points not addressed by Stokstad challenge this premise.

First, the culture of carnivorous species, such as salmon and trout, already represents a net drain on wild fish populations. Over 2 kg of wild fish are required to produce 1 kg of aquacultured conventional carnivorous fish (*1*). In North America and Europe, fish are usually reared in high densities and therefore rely completely on manufactured feeds for sustenance. Manufactured feeds for carnivorous species are typically composed of 35 to 50% fish meal and up to 20% fish oil (*1*). The accelerated growth rate of transgenic fish will necessitate an enormous increase in the usage of feeds and their constituent marine feedstuffs. Fish meal and fish oil are typically made from menhaden and anchoveta harvested from the wild. As these species are already being exploited near their maximum sustainable levels (*2*), using more of them to create even more feed for transgenic fish can hardly be considered an easing of pressure.

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Second, on the basis of the Law of Conservation of Matter, increased feed inputs will result in more outputs of waste in aquaculture effluents [e.g., (*3*)]. Reclamation of aquaculture waste is already problematic. In net-pen culture, for example, untreated wastes are expelled directly into the surrounding waters and commonly cause local eutrophication, buildup in sediments of feed-borne antibiotics, and benthic anoxia (*4*). Although the degree of these impacts depends on husbandry practices and the hydrodynamics of the site, the potential for serious environmental damage will increase with the increased feed usage required by transgenic fish culture. Add the potential effects of interbreeding between transgenic escapees and wild fish discussed by Stokstad, and transgenic fish culture appears more threat than boon to the wild fishery.

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Dealing with the Risks of Transgenic Fish

ERIK STOKSTAD'S ARTICLE "ENGINEERED FISH: friend or foe of the environment?" (News Focus, 13 Sept., p. 1797) correctly points out the risk to the environment associated with potential releases of genetically modified aquatic animals. This risk is a function of the specific genes, specific species and strain, and environment, and is independent of whether the genes came from genetic engineering, conventional breeding, or inadvertent selection.

The scientific research community must remain attentive to the details of how these very complex problems are being addressed. Researchers can become "collateral damage" to groups with agendas ranging from real environmental concern, to antitechnology, anti–genetically modified organism activists, to crass commercial interests.

In California, State Senator Byron Sher introduced legislation (*1*) SB 1525 that would have made it "unlawful to import, transport, possess… any live transgenic fish." When it was clear that this legislation would shut down many zebra fish researchers in California, it was amended to allow researchers to get a permit for noncommercial purposes only. This could still affect researchers by impacting zebra fish suppliers like Scientific Hatcheries and Exelixis, along with the added burden of another layer of permits. This bill with its amended variations and reincarnations posed a real risk to scientific research in California, before it was finally stopped for this year.

The proponents of a ban on transgenic fish (*2*) submitted a petition to the California Fish and Game Commission to adopt a moratorium on "transgenic" fish and stated that the moratorium would "specifically apply… [to] ornamental aquatic species, such as transgenic zebra fish." Senator Sher's letter of support (*3*) specified plans for "mass producing a transgenic form of these zebra fish" as "wrong." When the zebra fish research community heard about these plans and showed up at the Fish and Game Commission meeting on 29 August 2002, the proposal was defeated. Efforts are under way to find a solution to the real problem of unwanted gene movement in the environment, without impacting scientific research and other insignificant environmental risk situations.

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1. See info.sen.ca.gov/pub/bill/sen/sb_1501-1550/sb_1525_bill_20020220_introduced.html.
2. Letter to R. Treanor, California Fish and Game Commission by the Natural Resources Defense Council (NRDC), Institute for Fisheries Resources, Pacific Coast Federation of Fishermen's Associations (PCFFA) and The Ocean Conservancy, 23 July 2002.
3. Letter to M. Flores, California Fish and Game Commission, by State Senator Byron Sher, 30 July 2002.

Encouraging Academic Competition in Europe

THERE HAS BEEN CONSIDERABLE DEBATE ON what are seen to be unfair academic recruitment practices in European countries such as Italy and Spain ("Academic recruitment in Spain and Italy," D. Gui *et al.*, Letters, 2 Aug., p. 770; "Reforms spark more jobs—and protests," X. Bosch, News of the Week, 1 Feb., p. 781). A substantial problem lies in the fact that there is a lack of direct competition for funding among the universities of a specific country based on indicators of scientific performance.

Citation analysis, using the Institute for Scientific Information (ISI) database, could foster such competition. As a task force of the Italian Rectors' Conference (CRUI), we analyzed the subset of the ISI database encompassing the scientific production of authors affiliated with Italian institutions (*1*). We ranked Italian universities according to the number of published papers in 1995–99, their citations, and the number of citations received per paper published (impact). We then devised a productivity index (the number of papers per university researcher) and a visibility index (the number of citations per university researcher). We observed that, when data were adjusted for the number of academic researchers actually working in an institution, there were differences in rankings compared with unadjusted data (e.g., smaller universities could become higher in ranking compared with larger universities). This suggests that for comparison of scientific performance of different universities, one should also take into account the human resources available (productivity and visibility indexes). We believe that citation analysis, if endorsed at both national and local levels, may provide good opportunities for stimulating the growth of science in academic systems that are willing to increase the value of merit and genuine scientific interest.

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Species Biology and Conservation Funding

IN HIS POLICY FORUM "CONSERVATION priorities for Russian mammals" (16 Aug., p. 1123), L. V. Polishchuk notes that limited government financial resources are often devoted to the conservation of only a few, high-profile flagship species. He suggests that conservation resources should be divided between species on the basis of extinction risk and proposes a mathematical model using the chance of inclusion on the IUCN Red List of Threatened Species, as predicted by annual fecundity, to provide a more uniform allocation.

The implication that the amount of funding required to conserve a species is directly related to its annual fecundity may be an oversimplification. For example, different species face different threats, from habitat loss, to overexploitation, to conflict with, and persecution by, humanity. Mitigating these different threats will incur widely differing costs (*1*). Moreover, some threatened species will generate resources for their own conservation, either through sustainable utilization such as tourism or hunting, or through their public image and marketability by fundraising nongovernmental organizations (*2*, *3*). This should relieve pressure on limited government funding sources for use on species with lower commercial potential. Finally, conservation resources are often allocated to protecting areas that conserve a range of species, rather than to individual species per se, which may be a more efficient tool for biodiversity conservation (*4*). Prioritization for funding of individual species should therefore take into account the relative costs of their conservation, the existence of alternative funding sources, and the extent to which extinction risk is averted by funding multispecies protected area networks.

The search for unifying theories and models in conservation biology to direct policy is intensifying (*5*). The model proposed by Polishchuk may be a useful tool where species face similar environmental and human pressures or where other relevant data are lacking. However, such models mask the complexity inherent in conservation, which may limit their real-world applicability (*6*).

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6. T. Whitten, D. Holmes, K. MacKinnon, *Conserv. Biol.* **15**, 1 (2001).

Response

I AGREE WITH WALPOLE, SMITH, AND LEADer-Williams that species biology is by no means the only criterion for allocation of conservation resources among species. It is equally true that allocation decisions should not ignore the species' biology and conservation status. The golden mean between underrating and overrating biology in conservation policy is yet to be developed, however.

An applied aspect of my study is that conservation resources could be divided among species in proportion to their probability of extinction. Because this quantity is known for only a handful of species, I suggest, as a first approximation, allocating resources in accordance with species' chance of being on the IUCN Red List of Threatened Species, which is determined on the basis of annual fecundity.

Russian mammals at risk include the Siberian tiger.

CREDIT: CORBIS

In fact, the points discussed by Walpole *et al.* do not undermine this proposal. It is true that "different species face different threats," and, to make the situation even worse, those having similar fecundity may well differ in other biological traits. The fact, however, is that despite these effects, which tend to blur the relationship between fecundity and chance of listing, the latter holds up well and would probably be even stronger if confounding factors were equalized. Hence, this relationship ought to be taken into account when working out a conservation strategy.

Furthermore, it's true that "some threatened species will generate resources for their own conservation." But the point is that, regardless of the source of money, be it a visitor to a national park or the state budget, it is the sum total that is allocated according to chance of listing. I realize that fundraising nongovernmental organizations cannot often follow this strategy, because the marketability of the Siberian tiger does not compare with that of the Russian desman, but a governmental agency can. Finally, it's true that "conservation resources are often allocated to protecting areas that conserve a range of species." But the question is how to divide resources among species within a protected area. Species having a higher chance of listing would require, for example, a higher frequency of monitoring, making it possible to catch the first signs of trouble. Account-

ing for considerations made by Walpole *et al.* will thus help to elucidate the mode of application of the chance-of-listing approach, rather than limit its scope.

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Where Is the Missing Generation?

IT IS AMUSING TO HEAR SENIOR INDIAN scientists complain about the lack of leadership in Indian science today ("Missing generation leaves holes in fabric of research," P. Bagla, News Focus, 25 Oct., p. 733). Bemoaning the loss of past glory is typical of men (please note, there are few women in the senior ranks) who have fallen behind their times. Perhaps these gentlemen also believe that India would have been better off under the British. If indeed their complaint that there is a lack of leaders in the age group of 45 to 55 years is factually correct, who is to blame? It is this class in the age group of 55 to 75 years who have ruled the roost these past few decades and have brought Indian science to its present regrettable state. The complaint about brain drain is a familiar refrain. What does it matter if a million or so Indians emigrate, when 999 million have chosen to stay? Now that these aging fossils are being slowly weeded out by the the passage of time, perhaps the ground will be broken for the emergence of the "missing generation" of scientists. But from what Bagla reports, even this seems to be in doubt.

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A Clarification from the IEDT

ALEXANDER STONE'S ARTICLE "U.S. RESEARCH on sedatives in combat sets off alarms" (News Focus, 2 Aug., p. 764) misleads the reader into thinking that the Institute for Emerging Defense Technologies (IEDT) is working on the use of drugs as weapons on the battlefield in international military conflict. Nothing could be further from the truth.

In 1999, the IEDT produced a report to present the results of a literature search on calmatives. The literature search was never a part, nor ever considered a part, of any effort to create military weapons for the battlefield. Rather, it was intended to list possible humane alternatives to deadly force for crisis situations. The literature search was never directed, tasked, or funded by anyone or any organization within the Department of Defense.

Stone also inaccurately describes an investigation we are currently conducting at the request of the National Institute of Justice (NIJ) as a study that tries to gauge the effects on humans of breathing in an aerosolized mixture of calmatives (substances that depress or inhibit central nervous system function and produce tranquil or calm behavior) and pepper spray. In fact, we are conducting a 6-month feasibility study to investigate whether combining a state-of-the-art anesthetic in small, harmless doses with pepper spray might reduce the very violent reaction that often occurs when it is used in domestic law enforcement.

Stone's article also includes speculation implying that the IEDT could be being used in an effort to violate or circumvent the Chemical Weapons Convention. Neither the literature search nor the pepper spray study Stone describes is intended to be applied in a battlefield environment covered by the Convention.

The IEDT develops new, less-than-lethal approaches for homeland security and U.S. military response and also conducts assessments of existing technologies. Among its most recent successes is an inexpensive approach to equipping new or existing fences with the capability to detect, locate, and classify intruders.

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CORRECTIONS AND CLARIFICATIONS

NEWS OF THE WEEK: "Survey confirms coral reefs are in peril" by E. Pennisi (6 Sept., p. 1622). The caption beneath the photograph on the left on p. 1623 misidentified a fish as a Nassau grouper. The probable species is a saddleback grouper.

RANDOM SAMPLES: "Old map, new ink?" by E. Goldman, Ed. (9 Aug., p. 931). It was stated that the Council of Basel (1431–49) had convened in Belgium. Basel is a city in Switzerland, although it was an independent city-state in the 1430s, when the council took place.

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.