Marine Reserves and Fisheries Management

IN THEIR REPORT "EFFECTS OF MARINE reserves on adjacent fisheries" (30 Nov., p. 1920), C. M. Roberts and co-authors present data indicating that fishery yields have increased in waters adjacent to marine reserves in St. Lucia and east Florida. In many developing island nations like St. Lucia in the Caribbean, fisheries are seriously overexploited, and little or no fisheries management exists. In such cases where marine reserves are the primary means of control of fishing effort and catch, they can result in increased yields compared with a no-management scenario. However, the St. Lucia example is specific to coral reef fisheries and does not prove the global utility of reserves to fisheries.

In contrast to St. Lucia, the recreational fisheries in east Florida are stringently regulated. Currently, the bag limit for red drum is one fish per person, with a slot limit of 18 to 27 inches (~46 to 69 centimeters) long (*1*). What effect have these regulations had on sizes of red and black drum along the entire east coast of Florida? According to the Marine Recreational Fisheries Statistics Survey, the mean weight of red drum and black drum in east Florida has more than doubled since the 1980s (*2*). Although the reserves in the Merritt Island National Wildlife Refuge examined by Roberts *et al*. reportedly have provided trophy-size fish to a limited area outside their boundaries, "traditional" fisheries management has resulted in size increases across the entire fishery. Furthermore, it is estimated that 80 to 90% of reserves have not succeeded in meeting their management objectives, even in coral reef systems (*3*).

Letters to the Editor

Letters (around 300 words) discuss material published in *Science* or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or 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.

Before implementing new reserves, it would be wise to ask whether a reserve is the best strategy for managing a particular fishery, and how might current reserves be better managed so that they attain their fishery goals.

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References and Notes
1. Florida Fish and Wildlife Conservation Commission, *Red Drum Management Plan* (Specific Authority Art. IV, Sec. 9, Florida Constitution, chaps. 83–134, Laws of Florida, amended 1991).
2. Data were queried from the Marine Recreational Fisheries Statistics Survey available at http://www.st.nmfs.gov/st1/recreational/queries/index.html
3. G. Kelleher, C. Bleakley, S. Wells, *A Global Representative System of Marine Protected Areas* (World Bank, Washington, DC, 1995); J. Alder, *Coastal Manage.* **24**, 97 (1996); T. McClanahan, *Coral Reefs* **18**, 321 (1999).

St. Lucian trap fishermen have seen their catches nearly double in 5 years since marine reserves were established in the Soufrière Marine Management Area.

CREDIT: FIONA GELL

THE STUDY BY C. M. ROBERTS AND colleagues seems little more than a promotional tool for proposed no fishing zones styled as marine reserves. The authors conclude that marine reserves off the southwest coast of St. Lucia and the east coast of Florida have enhanced adjacent fisheries, but such a conclusion is overreaching, given the data they present.

In the latter case, for example, Roberts *et al*. examined data from the two reserve zones in the Merritt Island National Wildlife Refuge at Cape Canaveral. They conducted seine samples and report that they found more and bigger fish inside the area than outside where fishing was allowed. The study is presented as if the research were current, but no true dates are given for the seining. In fact, the seine samples go back to 1987–89 (*1*), a period when the fished waters were subjected to wanton commercial gill netting at its peak. In 1995, a Florida constitutional amendment finally banned the gill nets. This reform accompanied numerous new limits on recreational fishing. As a consequence, fish stocks have skyrocketed in the same fished area, as demonstrated in young-fish research projects by the state. So, all that Roberts *et al*. have shown is that when commercial pressures are curtailed, fish stocks thrive.

The authors bolster their conclusions about the Cape Canaveral marine reserves by listing a number of recreational fishing records supposedly set because of big fish migrating out of the reserves. However, before being closed to the public, the reserve waters (part of what was established as the Cape Kennedy security zone) were already known to harbor record specimens of certain species because of prime habitat. In addition, there was a spurt of records along Florida's east coast, largely as the result of line-class categories created by the International Game Fish Association, as well as $1000 awards paid by a line manufacturer. Importantly, many records were set in areas far removed from the reserve areas, including Mosquito Lagoon waters that are separated by land from them.

The real cause of perceived problems in fisheries management is the commercial take-for-profit. There is no justification for banning family-level angling, which is allowed in Yellowstone and Everglades national parks and other fragile areas. Good management does not require draconian prohibitions.

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References and notes
1. D. R. Johnson, N. A. Funicelli, J. A. Bohnsack, *N. Am. J. Fish. Manage.* **19**, 436 (1999).

THE CONCLUSIONS BY C. M. ROBERTS AND colleagues that the effects of the Soufrière Marine Management Area (SMMA) extended beyond its boundaries and that commercial

fish yields were increased because of the marine reserve are weak, for two reasons. First, there were no controls in the study and thus there can be no strong evidence for an effect of the experimental treatment. Second, the increase in abundance and catch outside the reserve was far too rapid to have been due to a buildup of a spawning population inside the reserve and export of eggs and larvae.

Regarding the second point, proponents of marine protected areas argue that spawning stock will build up inside reserves and eggs, larvae, and juveniles will then be exported to areas outside the reserves. For this chain of events to happen and for the exported eggs and larvae to grow to sufficient size for fishing would require time. Yet Roberts *et al*. report that the abundance outside the SMMA increased immediately after its establishment, despite the fact that fishing effort and catch increased outside the reserve. The rapid increase in abundance outside the SMMA could not have been due to increases in spawning stock inside. Alternative explanations for the data include an environmental change, as Roberts *et al*. suggest, or the effect of the experiment, which involved not only the establishment of the protected area, but "daily patrols by wardens," heightened public awareness, and other factors that could have contributed to improved compliance with existing regulations.

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Response

REGARDING TUPPER'S COMMENTS, FLORIDA recreational fisheries have certainly benefited from other management measures implemented over the period of our study, as he notes. However, marine reserves have additional benefits beyond conventional management approaches such as size or bag limits. They protect habitats, provide refuges for species highly vulnerable to fishing effects, and offer comparable levels of catch in adjacent fisheries at a lower risk of failure (*1*). On their own, reserves or conventional measures are usually not enough (although St. Lucia's fishery is recovering with reserves alone). In combination, they can have a powerful effect. We agree that inadequately protected reserves are useless, but our study shows that well-enforced reserves can be extremely effective and can play a critical role in achieving sustainable fisheries.

In the second letter, Wickstrom describes a previous study of the Cape Canaveral reserves co-authored by one of us, James Bohnsack (*2*). Although we referred to this paper, the timing of sampling in it is not relevant to the results we presented in our *Science* report, nor does it affect our conclusion that there are increasing numbers of world-record gamefish being caught adjacent to the Cape reserves.

Wickstrom articulates commonly held views among anglers for explaining the concentration of world records around Cape Canaveral. He suggests that record patterns can be explained by changes in management or fishing practices, or that habitats in the Canaveral area are unique. Florida has passed many beneficial conservation regulations in the face of increased demands from a population of 6 million rising to more than 16 million people since 1962. However, fishing regulations, the net ban, and promotions by fishing gear manufacturers are not consistent with the spatial patterns and the concentration of records around the Cape, because they apply statewide or to large regions.

The product promotion, for example, applied statewide. Actually, more Florida world records were reported for our study species in 1993, before the contest, than in 1994 (6 versus 3 black drum, 8 versus 4 red drum, and

Populations of high-value fish like these gray snapper have rebounded inside and outside marine reserves in St. Lucia.

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13 versus 6 spotted sea trout). The net ban is also a common explanation for record patterns, but it cannot account for our results, either, because it applied statewide and took effect in July 1995, years after world records from the Cape began increasing. Any records in response to the net ban would take years to become manifest and should occur throughout Florida. After the net ban, however, 18 of the 20 new world records from 1996 to 1999 were from the Cape. Wickstrom also mentions the addition of new line classes in 1981 by the International Game Fish Association, but this resulted in a spurt of new records adjacent to Cape reserves only for spotted sea trout. Steep increases in numbers of world-record red and black drum only came years later, after fish from the marine reserves had attained large enough sizes.

In the third letter, Hilborn says that our findings of rapid increases in biomass and catches after the creation of marine reserves in St. Lucia are weak because our study lacks controls. It is hard to find ideal controls for large-scale management experiments of this kind (which is one reason that fishery management measures almost never have controls; reserves could provide control areas to assess how well management is performing). We agree that it would have been preferable to track fish populations in comparable habitats elsewhere in St. Lucia, in addition to unprotected areas adjacent to reserves. But comparable habitats were unavailable, and if they were, they too might receive offspring of fish from reserves and so would not be ideal controls. However, as we noted in our report, a regional regime shift is an unlikely explanation for our results. Data we have collected in a parallel study from an island 460 kilometers to the north show no comparable increases in fish biomass over the same period (*3*), nor have we heard reports of increases from closer islands. We can also rule out the possibility that reserves in St. Lucia increased awareness of other management measures, because reserves were the only form of management.

Even though local experimental controls are often less than ideal, the veracity of results is greatly strengthened where they can be repeated. There are now many examples of marine reserves from different habitats and countries that show an equally rapid rebound of fish stocks to that we described for St. Lucia [reviewed in (*4*)]. The initial phases of such rebounds stem from the growth of fish already present, but enhanced recruitment will play an increasing role after several years of protection. The St. Lucia fishery depends mainly on small, short-lived, rapid-turnover species, and 5 years would certainly be sufficient for protected fish to reproduce and their offspring to grow to catchable size in adjacent fishing grounds. The close proximity of reserves and fishing grounds is also likely to have maximized opportunities for the fishery to benefit from spillover of adults and juvenile fish from reserves.

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References and notes

1. A. Hastings, L. Botsford, *Science* **284**, 1537 (1999); T. C. Lauck, C. W. Clark, M. Mangel, G. R. Munro, *Ecol. Appl.* **8**, S72 (1998).
2. D. R. Johnson, N. A. Funicelli, J. A. Bohnsack, *N. Am. J. Fish. Manage.* **19**, 436 (1999).
3. C. M. Roberts *et al.*, unpublished data.
4. B. Halpern, *Ecol. Appl.*, in press.

Long Road Ahead for Hydrogen Fuel Cell Cars

IN EARLY JANUARY, U.S. SECRETARY OF Energy Spencer Abraham announced the new program Freedom CAR (Cooperative Automotive Research), a cooperative effort with industry to develop cars powered by hydrogen fuel cells. As David Malakoff and Robert F. Service report in their News of the Week article "Bush trades hybrid for hydrogen model" (18 Jan., p. 426), this program replaces the Partnership for a New Generation of Vehicles (PNGV) begun in 1993 by the Clinton Administration that focused on developing more fuel-efficient cars (such as gas or diesel-electric hybrids) and other measures to reduce our dependence on gasoline. But what Malakoff and Service do not make clear is that hydrogen as a fuel for vehicles will not be available in the foreseeable

future except from natural gas or other fossil fuels. Until hydrogen can be obtained economically from water by means of solar energy or nuclear power in huge quantities, there is no point in talking about hydrogen to replace fossil fuels in cars.

I strongly support research on solar energy–derived hydrogen and other solar programs. However, for Abraham to give up on the PNGV program is shortsighted. The goal of the Freedom CAR program—or as Abraham calls it, his "dream car" (*1*)—is truly just a dream.

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References and Notes

1. S. Abraham, "Dream car made real," *New York Times*, 20 January 2002, section 4, p. 12.

What Counts in Conservation?

A RECENT COURT DECISION COULD REQUIRE hatchery fish to be counted as part of the populations of wild, imperiled salmon when assessing conservation numbers (News of the Week, "When is a coho salmon not a coho salmon?" by J. Kaiser, 30 Nov., p. 1806). The decision imperils many efforts to protect ecosystems. Rather than merely blaming the courts, it might be wise for scientists to consider how their own behaviors contributed to this state of affairs.

Through institutional narrowness and reductionism in science itself, ecology has been effectively restricted to biology, which in turn confines the problem of ecosystem loss to matters of fish production. With the more complex and contentious problems (cumulative loss of ecosystems over time) reduced to more manageable measures (fish production), the stage was set for a series of technological fixes, including the production of fish through the use of hatcheries. Arguing over the skill of hatchery fish (to forage and avoid predators) merely sets the stage for more refined technological fixes, such as changing the design and operation of hatcheries.

In contrast, the purposes of the Endangered Species Act of 1973 are "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Wild salmon are telling us that these ecosystems are not being conserved.

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CORRECTIONS AND CLARIFICATIONS

THIS WEEK IN *SCIENCE*: "Keeping blood pressure low" (18 Jan., p. 403). This summary of the report "Abnormal vascular function and hypertension in mice deficient in estrogen receptor β" by Y. Zhu *et al*. (p. 505) misrepresents the results of the research. An appropriate description is as follows. Zhu *et al*. examined vascular function in mice lacking the β form of the estrogen receptor (ERβ). In normal wild-type mice, estrogen attenuated the constriction of blood vessels by an ERβ-mediated increase in the expression of inducible nitric oxide synthase, with consequent increase in the production of the vasorelaxant agent, nitric oxide. In the animals lacking the ERβ, in contrast, estrogen augmented vasoconstriction. These animals also developed hypertension as they aged, which may yield new insights into the treatment of hypertension, particularly that associated with menopause.