

## **PROTECTING BIG OLD FAT FEMALE FISH AND STOCK SPATIAL STRUCTURE IN NETWORKS OF MARINE PROTECTED AREAS MAY HELP TO SUSTAIN GROUND FISH FISHERIES**

Many fisheries are in a state of decline. Here on the West Coast, eight out of 20 well-assessed species of Pacific Coast groundfish have been declared overfished, resulting in restrictive rebuilding plans that include large-scale shelf closures. While numerous factors have contributed to these declines, we believe that at least part of the explanation for these stock collapses is the result of our failure to appreciate the value of Big Old Fat Female Fish (BOFFFs) and the spatial structure of groundfish populations.

### **1. NOT ALL SPAWNERS ARE CREATED EQUAL – BIG OLD FAT FEMALE FISH ARE THE BEST FOR FUTURE FISH POPULATIONS, BUT ARE ALSO FISHERMEN’S FAVORITE TARGETS.**

It has long been known that larger (and presumably older) female fish produce a greater *quantity* of larvae than smaller fish. For example, a 40-cm bocaccio rockfish produces an average of just over 200,000 eggs per year, whereas an 80-cm fish at double the length produces nearly 10 times as many eggs (2 million!). New data, however, reveal that larval *quality* is also greater for offspring from older fish – quite simply, BOFFFs are the best. Older black rockfish females provide their larvae with significantly larger oil globules than younger females (the globule is a little droplet of oil that serves as a metabolic reserve after larvae are born and their yolk-sac has been absorbed). This allows larvae of BOFFFs to grow faster and enables them to withstand starvation longer than larvae from younger mothers, giving them a better chance to survive to become spawners themselves. The ability for larvae to grow faster has clear benefits because they can pass more quickly through vulnerable life history stages. Older black rockfish females also spawn earlier in the reproductive season than their younger counterparts, which often links the timing of larval birth with peak food availability.

Fishing, even at “sustainable” levels, truncates the age distribution of the population most directly by removing older fish (which are usually more valuable) and more gradually by removing younger fish before they can grow old. This means that BOFFFs are disappearing. For example, off the Oregon coast the average age of mature female black rockfish declined from 9.5 to 6.5 years during a period of intensified bottom fishing from 1996 to 1999. There is evidence for the value of BOFFFs and severe age truncation in other species, including Atlantic cod.

### **2. NOT EVERYONE IS METROPOLITAN – MANAGEMENT MUST PROTECT THE FISH IN SMALL TOWNS TOO.**

Current fisheries management practices assume that groundfish in a given species range or management unit are all part of the same unit stock, or reproductively closed population. For example, each rockfish species is assumed to comprise only one or two stocks along the entire West Coast of the United States. Recent studies have shown, however, that stocks may actually consist of multiple, reproductively distinct units. One study, for instance, determined that larval dispersal of black rockfish was more limited than previously believed, and that there are several different population divisions along the coasts of Oregon and Washington alone. Similar findings have occurred for copper rockfish, Pacific Ocean perch, and darkblotched rockfish. Many groundfish species exhibit complex population structures, and although they may be widely distributed, there may be only limited genetic exchange among geographically proximate locations. These results suggest that current stock assessments may be lumping several distinct stocks into a single management unit, which could allow overfishing of a reproductively distinct regional stock to go undetected. To reduce the risk of overfishing a stock component, management should strive to preserve a minimal spawning stock biomass throughout the geographical range of a species.

### **3. NETWORKS OF MARINE PROTECTED AREAS ARE UNIQUE TOOLS TO HELP GROUND FISH POPULATIONS RECOVER - THEY CAN PROTECT BIG OLD FAT FEMALE FISH THROUGHOUT THEIR RANGE, EVEN IN THE SMALL TOWNS.**

If the old growth age structure of groundfish populations (i.e., BOFFFs) continues to be eroded, and if smaller-scale spatial dynamics of populations are not taken into account, groundfish populations will continue to be at risk. Three methods of management can help to conserve BOFFFs in exploited populations: (1) low fishing quotas, (2) a combination of lower and upper size limits (i.e., slot limits), and (3) marine protected areas (discrete areas where fishing for targeted groundfish is prohibited). As long as the fish stay put, protected areas can provide a safe-haven for female fish to get big, old, and fat. The first scenario is usually economically unfeasible – because reduced exploitation must be extreme to allow many fish to reach old age, fishing is severely reduced. The Atlantic striped bass moratorium, for instance, lasted 5 years. The second scenario is often biologically unfeasible – groundfish often do not survive capture and release, due to rupture of their swim bladder or other capture trauma.

The third option, implementing a network of marine protected areas, offers the best and perhaps only way to ensure the persistence of BOFFFs and if properly sited, to allow for complex spatial dynamics, and therefore to help achieve replenishment and sustainability of groundfish stocks. While we believe that marine protected areas are necessary, they are not, by themselves, sufficient for management. Fishing will continue outside the protected areas, and traditional management tools will still be needed to ensure sustainable fisheries. Protected areas that represent different habitats within different biogeographic regions will protect older female fish, their high-quality larvae, and protect species throughout their ranges to counter the effects of overfishing reproductively-isolated populations.

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\* For more detail, see:

Berkeley, S. A., C. Chapman, and S. M. Sogard. May 2004. Maternal Age as a Determinant of Larval Growth and Survival in a Marine Fish, *Sebastes Melanops*. *Ecology* 85:1258-1264.

Berkeley, S. A., M. A. Hixon, R. J. Larson, and M. S. Love. Aug. 2004. Fisheries Sustainability via Protection of Age Structure and Spatial Distribution of Fish Populations. *Fisheries* 29:23-32.

Palumbi, S. R. Aug. 5, 2004. Why Mothers Matter. *Nature* 430:621-622.