

## Do Marine Protected Areas Really Work?

**Georges Bank experiment offers new insights on age-old questions about closing areas to fishing**

By Michael J. Fogarty, Adjunct Associate Scientist, Woods Hole Oceanographic Institution and NOAA Fisheries, Northeast Fisheries Science Center and Steven A. Murawski, Director, Office of Science and Technology, NOAA Fisheries, Silver Spring, MD

Closing parts of the ocean to fishing to preserve fish stocks holds great intuitive appeal. Similar resource management tools have been used as far back as the Middle Ages, when European kings and princes controlled access to forests and streams, and the fish and wildlife in

them. In Hawaii, local chiefs established and maintained networks of no-fishing “kapu” zones, with violations punishable by death.

Today, Marine Protected Areas, or MPAs—areas of the ocean temporarily or permanently closed to harvesting—are being proposed to restrict not only fishing, but also mineral and hydrocarbon extraction, and other activities. Some advocates of MPAs suggest that at least 20 percent of the coastal and open ocean should be set aside and permanently

zoned to protect ecosystems, sustain fish stocks, and reduce conflicts between users of the oceans.

But the key question remains: Do MPAs really work? It is the modern incarnation of a longstanding question: How can we best ensure sustainable fisheries?

### A Victorian model

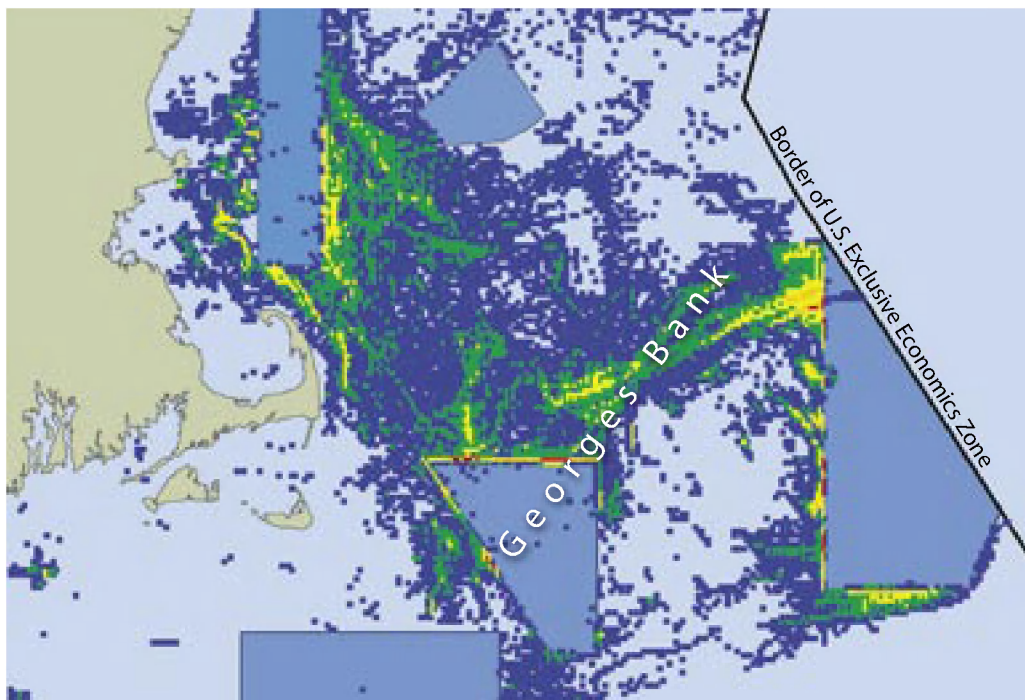
In the 19<sup>th</sup> century, scientists vigorously debated the effects of fishing on fish populations and ecosystems. A majority of scientists accepted the paradigm that

the oceans were unlimited.

Thomas Henry Huxley, a pre-eminent Victorian naturalist, famously stated in 1884 that,

“... the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea-fisheries, are inexhaustible; that is to say that nothing we do seriously affects the number of fish ... given our present mode of fishing. And any attempt to regulate these fisheries consequently ... seems to be useless.”

The debate culminated in one of the first documented experiments to determine the effects of fishing. In 1886, one bay in Scotland remained open while another was closed to fishing for 10 years. The focus of the experiment was plaice, a valuable commercial fish. Over the decade, plaice in the closed bay increased significantly compared to plaice



Michael J. Fogarty and NOAA Fisheries

**FISHING AT THE BORDERS:** Georges Bank and surrounding areas with a long history of abundance, has seen fish stock depletion and collapse of the fisheries. To speed stock recovery, parts of the area have been closed to fishing as Marine Protected Areas (MPAs), shown as dark blue polygons. Dots indicate fishing effort in 2003, based on satellite tracking of vessels moving at less than 3-5 knots and assumed to be towing fishing gear. Warmer colors (green to red) denote more intense activity. The highest intensity of fishing occurred right at MPA borders, indicating that fishers expected greater abundance there.



Dann Blackwood and courtesy of Dr. Poge Valentine, USGS

**THE DIFFERENCE A DREDGE MAKES** – The severe damage done to sea bottom habitats and organisms by dragging fishing gear over the bottom is chronicled in these images. The first photo is a normal seafloor community on Georges Bank, and the second shows a similar area after dredges have been used to harvest scallops.

in the open bay. It was an early, instructive demonstration that fishing does have impacts on fish populations, and that regulation is effective for conservation.

### Some ABCs of MPAs

Since then, seasonal and longer-term closures have been an important fishery management tool, and they have protected spawning fish and nursery areas, preserved vulnerable habitats, and reduced fishing pressure.

But by themselves, MPAs cannot attain all of today's fishery management objectives. And they can create unintended consequences. Preventing harvesting in some areas, for example, inevitably results in people fishing in other, perhaps more vulnerable, locations.

MPAs have now been established throughout the world ocean, from the tropics to the poles. Most are relatively small. Many are neither adequately enforced nor monitored to determine their effectiveness.

Of those that have been scientifically monitored, many are in tropical and subtropical areas. Fish in these regions live their whole lives in specific habitats, such as reef structures, and don't stray from them. Their fidelity to a small territory is an important part of the potential success of their marine reserve. Populations do increase in such reserves, and some studies suggest a spillover effect from the

reserve that augments fisheries nearby.

By contrast, in temperate, boreal, and subarctic systems—where most of the major world fisheries reside—many fish populations are wide-ranging, and often exhibit extensive seasonal migrations. Can a reserve by itself be a successful fishery management tool for these fish?

### The Georges Bank 'experiment'

In 1994, federal regulations established a number of year-round fishery closures on Georges Bank and adjacent areas. This shallow bank has sustained fisheries of legendary abundance for hundreds of years until the mid-20<sup>th</sup> century, when the heavily fished stocks declined steeply.

The year-round closures evolved from seasonal closures established in the 1970s by the International Commission for Northwest Atlantic Fisheries to protect spawning groundfish, particularly haddock. The current year-round closed areas—on Georges Bank and two nearby areas—encompass more than 20,000 square kilometers. It is one of the largest systems of closed fishing areas now in effect. In addition, a mosaic of seasonally closed areas in the Gulf of Maine eliminates fishing in virtually all parts of the gulf at one time or another.

At the same time, the National Oceanic and Atmospheric Administration also restricted the number days at sea that fishermen could fish. Fishing by trawlers

declined by more than 40 percent over the next five years, although fishing with static gear, such as lobster traps, gillnets and longlines, and limited scallop harvesting, is still allowed in the closed areas.

These closures have given us a unique opportunity to examine a marine protected area in a temperate system under a "macroscopic"—to examine how marine ecosystems are structured and how they function and recover. The long history of research on Georges Bank adds a foundation of scientific knowledge that makes the Georges Bank MPA an ideal system to test the effects of year-round fishery closures.

### In the aftermath of closures

We have several ways to assess the Georges Bank and nearby MPAs. We have monitored fish and shellfish populations to get detailed comparisons of abundances and sizes of animals within and outside the closures, both before and after the establishment of the MPAs. Together with information from the commercial fishery and from scientific studies, the results let us see the impacts of the closed areas on seafloor organisms and communities, on the physical structure of the habitat, and on population levels of fish and shellfish species.

It is not easy to separate the effects of the closed areas on Georges Bank from other changes, such as fishing-days reductions implemented at the same time. How-

ever, our studies show that the closures have played an important role in the overall increase in abundance of these stocks:

- The biomass (total population weight) of a number of commercially important fish species on Georges Bank has sharply increased, due to both an increase in the average size of individuals and, for some species, an increase in the number of young surviving to harvestable size.
- Some non-commercial species, such as longhorn sculpin, increased in biomass.
- By 2001, haddock populations rebounded dramatically with a fivefold increase.
- Yellowtail flounder populations have increased by more than 800 percent since the establishment of year-round closures.
- Cod biomass increased by about 50 percent by 2001.
- Scallop biomass increased 14-fold by 2001, an unintended benefit of the establishment of closed areas to protect groundfish.

### Eggs and larvae to seed the seas

Despite increases in biomass, MPAs only benefit a fishery if fish eggs and larvae are exported from closed areas to replenish open, harvested areas, and/or if some harvestable-size stock “spills over,” moving from closed to open areas to be caught. But if fish at any age leave closed areas at high rates, it will prevent a build-up within the reserve and cancel out any positive effects from the MPA.

Estimating the export of eggs and larvae is extremely difficult. But we can use the location of spawning aggregations and hydrodynamic models to estimate the magnitudes and directions of eggs and larvae dispersal.

On Georges Bank, a key factor in larval dispersal is a well-established clockwise circulation pattern, or gyre, resulting from factors including local tidal forces and seafloor topography. The gyre creates a conduit that may allow eggs and larvae to self-seed closed areas, cross-seed other closed areas, and transport larvae to open areas. Our analyses for scallop larvae in-

dicate that the closed areas on Georges Bank can be self-sustaining and also contribute to recruitment into other areas.

### Spillover and trawling impacts

Our initial findings on spillover amounts show that the MPAs have benefited some species, but not all. Using information from the commercial fishing fleet, we found significant spillover for haddock and for yellowtail and winter flounders near some closed areas, but no spillover for other commercially important species.

But the commercial fleet clearly expects spillover from the MPAs. Satellites tracking shows that large trawlers concentrate their fishing efforts on the borders of the closed areas, poised to pounce on any fish that strays over the boundaries.

Scientists from the Northeast Fisheries Science Center, University of Rhode Island, and the U.S. Geological Survey have documented the impacts of mobile fishing gear, such as bottom trawls and dredges, on bottom-living (benthic) communities of organisms. Comparing detailed photographic images of sites inside and outside the Georges Bank closed areas, they have measured the damage done to the seafloor.

The difference is striking: We can see the recovery of benthic organisms inside the closed areas and watch com-

munity structure re-emerge, as a result of the MPA.

### Benefits beyond fisheries

The large-scale management experiment on Georges Bank indicates that a combination of MPAs and other management measures, such as reduced fishing efforts, can allow some species to recover from overexploitation. And beyond protecting fisheries, MPAs potentially offer other benefits. They can:

- help preserve marine ecosystems and biodiversity of species not targeted by a fishery but impacted by it through trawling damage or inadvertent catch
- promote non-extractive uses of marine areas, like eco-tourism
- establish undisturbed locations for scientific studies that can further improve resource management and conservation.

To make the best use of MPAs, though, we have to clearly specify our objectives. We then must evaluate the effectiveness and the social and economic impacts of MPAs and compare the utility of MPAs with other possible management tools to see if they are the best option for the situation. The Georges Bank experience has proven very instructive in how to implement and evaluate marine protected areas in temperate seas—and the experiment is still going strong.



Anne Richards



NEFSC

Michael Fogarty started life far from the ocean, in Fairbanks, AL. His parents, New England natives, eventually returned to Rhode Island, where he became fascinated with sea life and embarked on a career in marine biology. He received a doctorate from the University of Rhode Island and came to the Northeast Fisheries Science Center in 1980, where he studies changes in marine ecosystems in response to fishing. He has served on numerous national and international panels and committees including the Scientific Steering Committee of the U.S. GLOBEC program, which he chaired from 1997-2002, the Global Ocean Observation System (GOOS) Steering Committee, and the Coastal Ocean Observation Panel of GOOS. When not keeping the world safe for fish, he serves as a full time chauffeur for his children, ages 9 and 12, who lead very busy lives.

Steve n Murawski spent his formative years in Kansas and Texas, before moving to New England as a teen. Interested in fisheries and the ocean since he was a lad, he obtained his degrees at the University of Massachusetts-Amherst. Since coming to the Northeast Fisheries Center he has been involved with determining how many fish of various species are in the ocean, and how many should be caught—the process of stock assessment. Murawski will soon be the Director of the National Marine Fisheries Service's Office of Science and Technology. He lives in Massachusetts with his wife Joni, daughters in high school and college, and a golden retriever, Sunshine.