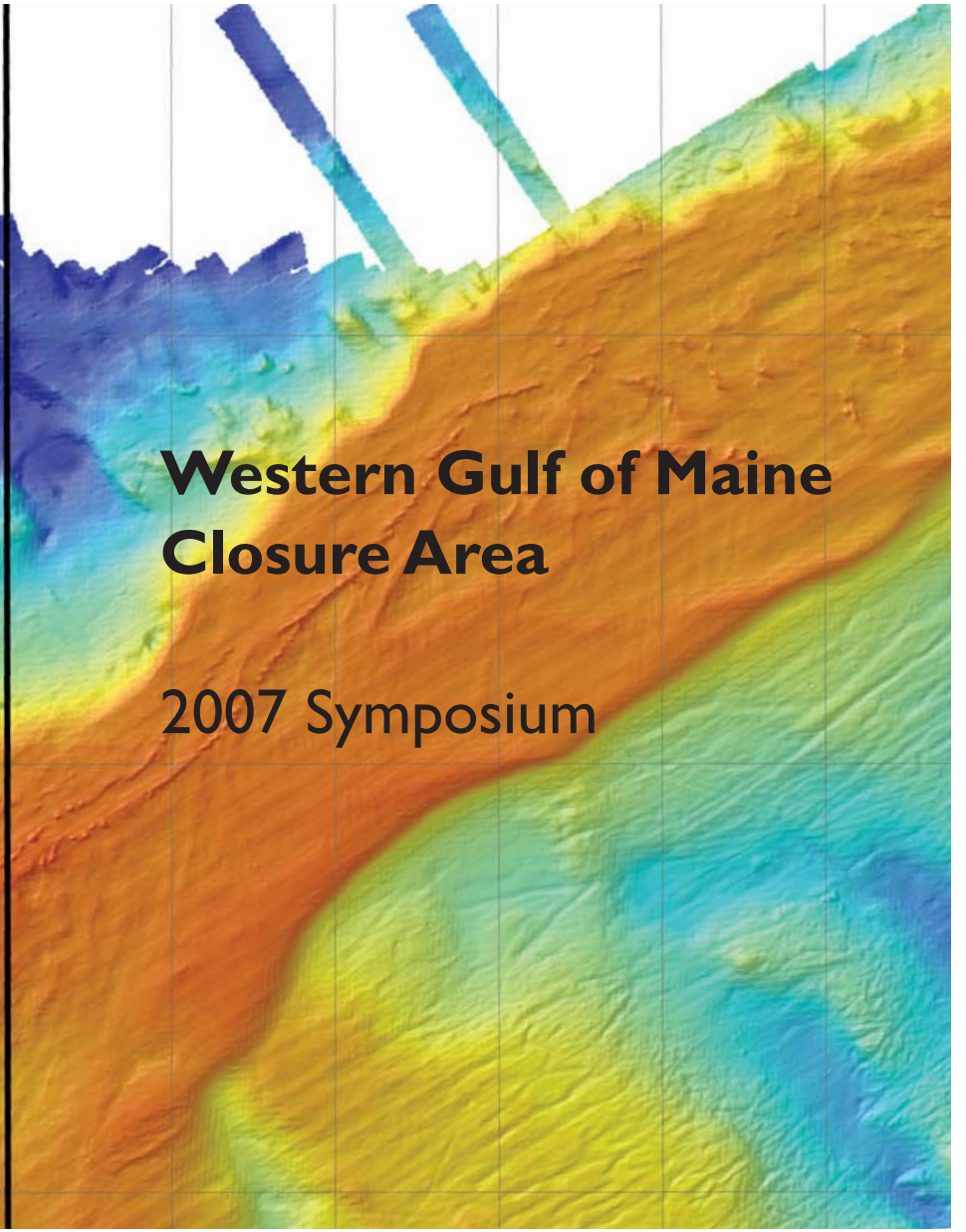


Western Gulf of Maine Closure Area

2007 Symposium

March 26, 2007
Elliot Alumni Center
University of New Hampshire

The cover illustration is a high-resolution bathymetric map providing unprecedented detail on seabed topography in a portion of the WGOMCA. Larry Mayer and his lab at UNH's Center for Coastal and Ocean Mapping generated the map using multi-beam sonar as part of a multi-investigator project funded by the Northeast Consortium.

A few words of thanks:
The WGOMCA 2007 Symposium and this publication required the time, talents and resources of a range of individuals and organizations. The symposium convenors, **Ray Grizzle** of the UNH Department of Zoology, **Ken La Valley** of NH Sea Grant and UNH Cooperative Extension, and **Rachel Gallant** of the Northeast Consortium, would like to thank the presenters who shared their work, thoughts and plans with the participants. They would also like to express their great appreciation and gratitude to **Holly Bayley '07**, **Caitlin Cavanaugh '08** and **Pauline Galardi '08**, three UNH students who tackled coauthoring, coediting and codesigning this publication as part of the University's Technical Writing 502 course; to **Steve Adams** of NH Sea Grant who worked with them to achieve those ends; to **Chris Manning** of the Northeast Consortium for his work in documenting the event; and to **Troy Hartley** of the Northeast Consortium for facilitating the symposium discussions. Finally, they would like to thank the UNH Marine Program, NH Sea Grant, UNH Cooperative Extension and the Northeast Consortium for funding the symposium and this publication.

Western Gulf of Maine Closure Area 2007 Symposium

Introduction

For almost a decade, the Western Gulf of Maine Closure Area (WGOMCA) has been a predominant fisheries management strategy for the Gulf of Maine. The Closure was established to protect spawning and nursery areas of key species, maintain age structure by retaining older and proportionately more fecund individuals, protect key habitats, and reduce bycatch of overfished and threatened stocks. With the increased drive to manage fisheries with more holistic approaches, it is important to rigorously evaluate current and proposed management strategies and the impacts they are having on the environment and traditionally harvested species.

The Western Gulf of Maine Closure Area 2007 Symposium was held at the University of New Hampshire on March 26. The meeting was open to the public and drew more than 80 commercial and recreational fishermen, scientists, fisheries managers and representatives of non-profit organizations, all eager to share their knowledge and collaboratively develop answers to the following questions:

- Is the Closure meeting its goals?
- What are the effects of the Closure?
- How far have we come in understanding the Closure?
- What future research is needed to evaluate the Closure?
- What does the future hold for the Closure?

We hope you find this publication a useful snapshot of the symposium and an aid in determining the utility of the Closure and its appropriate management.

Ray Grizzle
Jackson Estuarine Laboratory

Ken La Valley
New Hampshire Sea Grant

Rachel Gallant
Northeast Consortium

Management of the WGOMCA

***Tom Nies**, Senior Fishery Analyst, New England Fishery Management Council*

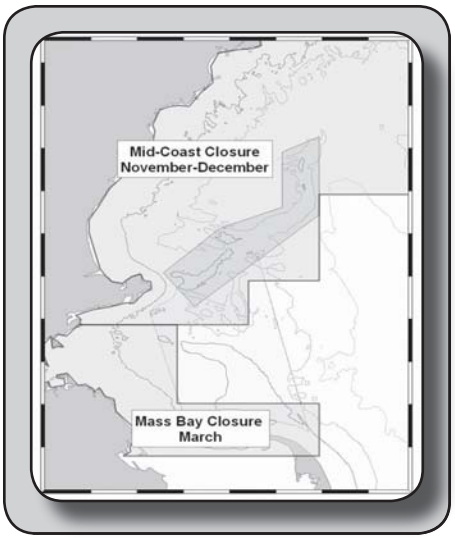
Tom Nies presented a history of the Closure within the context of other fisheries management measures in the region. He then talked about whether the Closure is meeting its goals, pending management actions that could influence the Closure, and information gaps that still exist and must be filled in order to evaluate the success of the Closure.

Management History

The Western Gulf of Maine Closure Area, as currently defined, was created in 1998 with Framework 25 to the Multispecies Fishery Management Plan (FMP). However, the first restrictions on commercial fishing in the area were in 1994 with FMP Amendment 5. This established a juvenile cod protection area on Jeffrey's Ledge and required extensive new regulations on minimum mesh sizes, minimum size limits, new fishing permits and logbook reporting. The goal was to reduce fishing effort on cod, haddock and yellowtail flounder stocks by 50% over five years. In addition, Amendment 5 established the days at sea (DAS) program. Closure boundaries, seasons and purposes were adjusted several times in the following years.

In 1996, Amendment 7 was passed. The objective of Amendment 7 was to broaden and reinforce regulations enacted under Amendment 5; areas that were closed to sink gillnet vessels were now closed to all fishing vessels. Amendment 7 also recognized that more clo-

sures would be developed and set up seasonal closures along the coast. The seasonal closures from November to December were unpopular with fishermen, because demand and prices were high during these times.



On Oct. 6, 1996, Framework 19 replaced the seasonal closures enacted by Amendment 7 with a one month closure in March. Gillnet closures were also modified. Framework 25 (1998) established seasonal (rolling) closures and the WGOMCA as a year-round closure. The WGOMCA was to be in place for three years. The purpose of these closures was to specifically reduce cod landings. The closures excluded commercial groundfishing gear, but allowed other fishing activities, such as recreational fishing, shrimp trawling and eventually herring midwater trawling in 2001. The WGOMCA boundaries remained the same through subsequent frameworks and were extended to 2002 by Framework 33. A court order then extended the Closure until the next major management action, the 2004 FMP Amendment 13.

Many fishermen were interested in modifying the Closure parameters to restore access to several stocks thought to be in healthy condition, such as pollock, haddock, witch flounder and plaice. From 1999 to 2004, Amendment 13 explored options to modify the Closure boundaries, however none were adopted.

Under Amendment 13, a new purpose for the Closure was to minimize the impacts of fishing on essential fish habitat. Bottom tending mobile gear was prohibited indefinitely in most (but not all) of the WGOMCA. The Scallop Amendment 10 lawsuit resulted in the prohibition of scallop trawls and dredges indefinitely throughout the entire area. Since 2004, there have been a few proposals to allow commercial fishing within the Closure using rod/reel or fixed gear, but none have been approved.

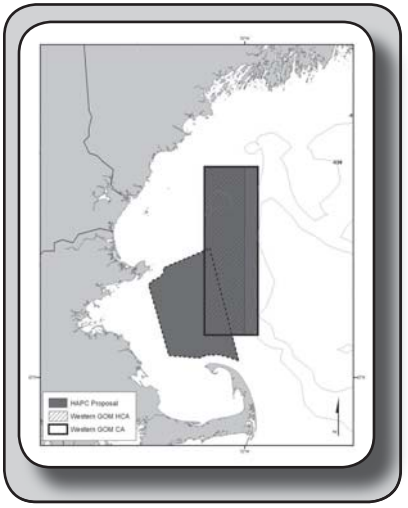
Does it Work?

From a regulatory perspective, the original goal was to reduce cod landings. This was expanded to include protection of essential fish habitat by Amendment 13. However, it is difficult to analyze the specific effects of the WGOMCA, mostly because additional management measures (rolling closures, trip limits and changes in gear sizes) were put in place at the same time. These measures collectively reduced mortality on GOM cod through 2002, but cod mortality rose in 2003 and 2004. These measures did not stop groundfish fishing altogether. Recreational fishing continues within the Closure. Recreational fishing has accounted for as much as 30% of the total cod removals from the GOM, and as much as half of that may be caught in the WGOMCA.

Two studies examined the commercial catch rates as a function of distance from the closed area. Surprisingly, there was no increase in fish landings closer to the boundary of the closed area as had been expected. This begs the question: Are cod using the Closure as a refuge? And if so, why are we not observing a spill-over effect at the boundaries?

Next Steps

Work on the next change to the groundfish plan, Amendment 16, has begun. Management intends to finish reviewing Amendment 16, scoping public comments and narrowing alternatives in 2007. Two viable alternatives would move away from the DAS system. The amendment may move away from using closures to control fishing mortality, especially the rolling closures but possibly the WGOMCA as well. Any changes to the closure boundaries must also consider the impacts on protection provided to essential fish habitat. The Omnibus Habitat Amendment will include habitat areas of particular concern (HAPC). HAPC may not necessarily change management measures. A Jeffrey's Ledge-Stellwagen Bank HAPC will be considered. The public comment period is expected to begin in April 2007. The final vote is anticipated for September 2008, and Amendment 16 will be implemented sometime in May 2009.



Information Gaps

Management of the Closure would benefit from answers to the following questions:

- Can fishing mortality impacts of the closed area be separated from the mortality impacts of other measures?
- What happens to fishing mortality if closure boundaries are changed?
- Are there spill-over effects from the Closure?
- Can the Closure-related benefits to habitat be quantified?
- Can the benefits to habitat that result from the Closure be directly linked to stock rebuilding?

A Mixed Blessing: Tracing the Effects of the WGOMCA on New England's Commercial Fishing Fleet

Madeleine Hall-Arber, *Anthropologist, MIT Sea Grant College Program*
Kevin St. Martin, *Geographer, Rutgers University*
Caroline Butler, *Anthropologist, University of Northern British Columbia*

By amending the Magnuson Stevens Fishery Conservation and Management Act in 1996, the Sustainable Fisheries Act strengthened the requirements for social and economic impact assessments of changes in fishery management regulations. In particular, the 10 national standards that were implemented by the act include a requirement that negative impacts on fishing communities be mitigated to the extent possible within the bounds of preventing overfishing. This suggests that managers must be cognizant of an implied balance that should be struck between the needs of fishing communities and fish stocks.

Madeleine Hall-Arber addressed the social impacts of the WGOMCA. This is a challenging prospect since the Closure is just one of a multitude of changes in the regulation of groundfish that have had social impacts. Furthermore, the WGOM year-round closure was part of a framework adjustment to the Multispecies Fishery Management Plan and therefore was not specifically included in the environmental impact statement (EIS) written for Amendments 5 and 7 to the groundfish plan. Nevertheless, a review of interviews of fishing community members from projects

conducted in the region over the last 10 years reveals a rich fund of knowledge and opinions about the effects of the Closure. Interestingly, the views expressed are not limited to the negative impacts on traditional shore-based communities, but often pertain to unanticipated consequences of the regulatory measures on the ecology of the area. In addition, some of the interviews reveal the evolving nature of community, further complicating the analysis of impacts.

> *"Some of the rules have good intentions, but they end up backfiring, and they end up backfiring on us." (Groundfishermen, June 1997)*

Cumulative Impacts of the Closures

The combination of rolling closures, days-at-sea (DAS) reductions and trip limits have compounded the effects of the WGOMCA, resulting in negative social and economic impacts on fishing families and communities. Furthermore, the intertwining of regulations has created perverse incentives that encumber the potential ecological benefits of the WGOMCA. Specifically, the rolling closures have created a short-term derby fishery, limits on DAS have compelled fishermen to reduce their geographic distribution and to target cod, and trip limits on cod have led to devastating levels of discards. Nevertheless, fishermen do recognize what they perceive as the benefits of the Closure including an increase in cod and haddock "coming out of that closure."

Ecological Impacts

The Western Gulf of Maine has been a preferred fishing area for many generations. Its proximity, as well as the variety of bottom types and mixture of commercially important species, created a fertile fishing ground within a safe steam of small boat operators' home ports. Fishing practices and traditions within the area have been passed along generational lines, building a rich cultural history.

The rolling closures were instituted to protect spawning cod. If the timing missed the precise period, the goal was to at least protect the aggregations of cod typical of before and after spawning. However, with the WGOMCA and the rolling closures, the active fishing grounds are severely compressed and fishermen "pound the bay to death." Also, when the monthly closures reopen, a derby fishery ensues.

Not only do the rolling closures make fishing grounds moving targets, the fishermen also face frequently changing trip limits on cod and haddock. The ecological and psychological problem, of course, is that since groundfish tend to be caught in the same general vicinity, trip limits often result in high levels of discards. Many fishermen say they are horrified by the waste. One suggested reducing discards by permitting a running clock (landing whatever you catch when you catch it, but not being allowed to fish again until the time had passed that would have permitted that amount). Another suggested allowing donations of extra fish to charity.

As the fishermen note, limits on DAS place them under a great time pressure, leading to crowding and other issues that diminish the benefits of the WGOMCA.

> *"The more rules and regulations they put in, especially cutting back on DAS, you want to try to fish as close to home as you can, so you burn up less time steaming." (Madeleine Hall-Arber)*

Changes in Fishing Patterns

The fishing industry of the Northeast once had a very diverse and flexible fleet, with a wide range of vessel sizes and target species that changed with the seasons, movement of the fish, knowledge and the preferences of the vessel captain/owners. Herring, mackerel, shrimp and whiting dominated the landings of some of the top ports. Floun-

der, cod and haddock were also part of the "annual round" of fishing. However, current regulations have removed flexibility and the fleet as a whole is less diverse.

Ironically, one of the unanticipated effects is that cod, the fish that is driving management to increasingly strict regulations, has become the primary target of the remaining fishermen in their own effort to survive. The WGOMCA and the rolling closures block access to traditional grounds and the limitation on the DAS forces the fishermen to catch whatever species can be caught quickly and sold for a relatively decent price.

Social Impacts: Numbers of boats, crew size, ownership and safety
The number of fishing vessels and crewmembers have significantly diminished in the Northeast region as a result of the cumulative impacts of regulatory change in the management of groundfish. The Closure contributed to this change since smaller vessels, including longliners and flounder boats, could no longer safely reach "hard bottom." The larger vessels were affected by the DAS limits.

The cumulative impact of the regulations has also led to changes in the structure of the fleet. When groundfish management started in earnest in the mid-1990s, the New England fleet was comprised primarily of vessel owner-operators. Recently, there has been significant consolidation of the fleet. Several individuals now own multiple boats and/or multiple permits, others stay in business by buying or leasing additional DAS.

Other fishermen have adapted to the regulations by reducing their costs, sometimes in ways that compromise safety. Some who have paid off their boat mortgage have dropped insurance. Some have stopped taking crewmembers, rigging their boats to allow them to fish alone.

Community Impacts: Aging of the industry and infrastructure
Fewer young people are moving into the industry because of the costs of entry, struggles with regulatory constraints, and anxiety over the

future. The cumulative impact of regulations led to an exodus from the groundfish fishery when a vessel buyout program was offered. Since then, many of the ports have been struggling to maintain their commercial fishing infrastructure.

If New England was a closed system, the price of groundfish would have reflected a lower supply by increasing, but instead the ex-vessel prices often go down rather than up. The rolling closures contribute to the unpredictability of supply, one of the leading constraints on prices. If supply is not regular, dealers seek a source that is more reliable such as frozen imports. Other processors who are unable to obtain a dependable supply either go out of business or change their product line. Therefore, even if the stocks rebound, fishermen and their communities are not optimistic that the infrastructure will be sufficient to support the increases in catch.

Resilience of Fishing Communities

As regulations have reduced the number of active fishermen and forced those remaining to fish in close proximity to one another, even when from different ports, a surprising unity seems to be evolving that includes sharing of local ecological knowledge, fishing equipment and techniques, as well as a broader discussion of management and social issues. It may be possible to build on this enlarged network of fishermen and fishing industry participants to develop a more nuanced system of management that will allow fishing industry members and communities, scientists and managers to succeed in their efforts to rebuild groundfish stocks.

Many of the fishermen interviewed do not dispute that there are benefits of the WGOMCA. The industry is concerned about the unintended consequences or cumulative impacts of this and other management efforts. While the WGOMCA may be partially responsible for an increase in cod in the inshore area, the rolling closures, DAS and trip limits have led to a loss of much of that benefit.

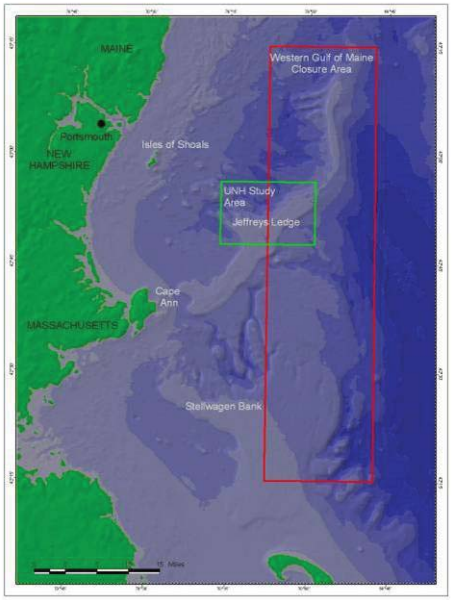
Recovery of Seafloor Habitats Inside the WGOMCA and Some Potential Impacts on Groundfish Populations

Ray Grizzle, *Research Associate Professor, University of New Hampshire*

Ray Grizzle presented results of two recently completed studies funded by the Northeast Consortium, one of which was co-funded by the UNH/NOAA Atlantic Marine Aquaculture Center. In his talk, he addressed two main questions:

- What are the effects of the Closure on bottom habitats?
- What research is still needed?

In his research, Grizzle attempted to find what effects the WGOMCA has on bottom habitats and how groundfish populations are responding to the Closure. Both studies were designed as control/impact studies. Ideally, before/after comparisons would have been made, but before data does not exist for the Closure.

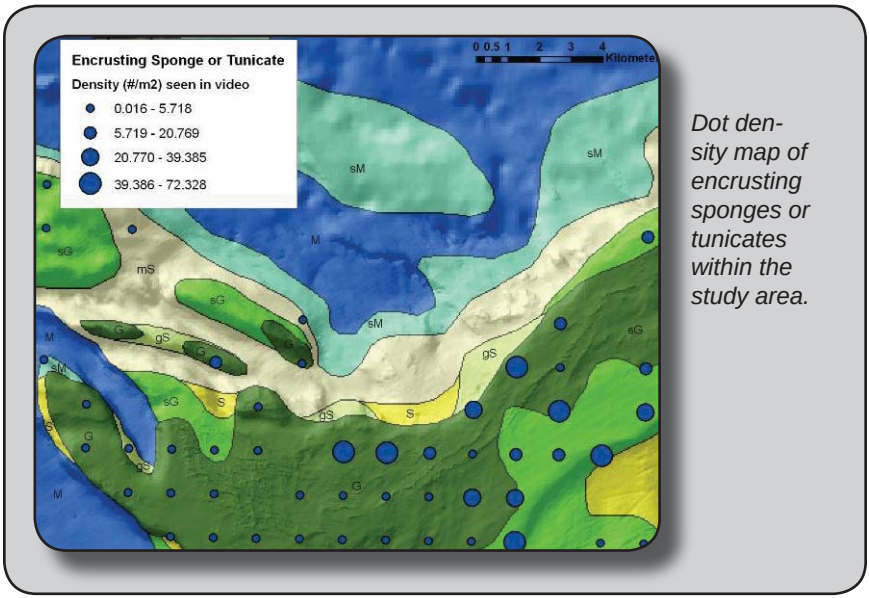


The UNH study site in comparision to the WGOMCA.

Bottom Habitat Recovery 2002-2005

Over the past two years, 190 out of the total 216 target sites have been sampled for epifaunal and infaunal communities within and outside the Clo-

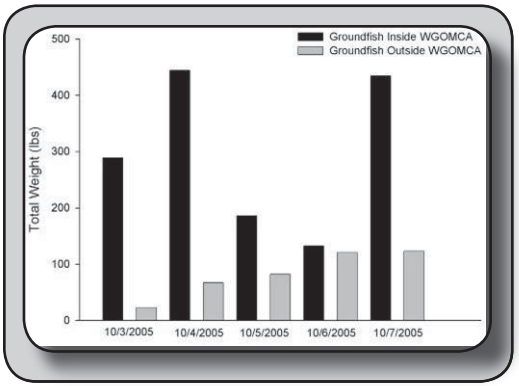
sure. This was done using underwater camera and sediment data gathering techniques. The data analysis for these sites is still under way. Infaunal community analysis resulted in six cases of significant differences between inside and outside the WGOMCA. Infauna showed the most increase in sandy sediment along Jeffrey's Ledge. There was up to four times higher density, biomass and taxonomic richness inside the Closure 30 to 50 fathoms deep along the edge of Jeffrey's Ledge. No significant differences were found in soft sediments in the basin or on rocks on top of Jeffrey's Ledge. The largest increases in epifaunal communities were found along the top of Jeffrey's Ledge on gravel sediment and were up to 2.5 times higher in the Closure. No significant differences were found in soft or sand sediments.



Dot density map of encrusting sponges or tunicates within the study area.

Grizzle considered the increases in density, biomass and taxonomic richness as an indication of recovery of the WGOMCA. Fishing gear disturbs the benthic environment. Closing the area has stopped the disturbances from trawls and gillnets. When left undisturbed, the seafloor rebounds by way of ecological succession. As succession proceeds, density and biomass increase.

Groundfish Populations in Rocky Habitats (2005 preliminary data)
The objectives of this study were to develop sampling protocols for juvenile groundfish in rocky habitats and to provide preliminary data on how the Closure may be affecting juvenile habitat.



A substantial difference in groundfish caught inside versus outside the WGOMCA was observed. Almost twice the number of fish and four times the biomass were observed inside compared to outside the Closure. Are restored benthic communities responsible for increased fish stocks in the closed area?

Future Research
The WGOMCA has an effect on the seafloor and groundfish. Benthic communities have recovered substantially. Preliminary results show increased numbers and biomass in the closed area. These conclusions lead to a need for more research focused on the following questions:

- How is the Closure area affecting fish stocks?
- Is the Closure serving as a refuge for juvenile and/or adult groundfish?
- Is the Closure contributing to stock rebuilding?
- Should target levels of diversity be identified?
- How are benthic characteristics related to the recovery of groundfish populations?

An Industry Perspective of the Impacts of the WGOMCA

***Peter Kendall**, Commercial Fisherman, Rye, NH*

Peter Kendall entered the fishing industry in 1995 and now manages the Portsmouth Fishermen's Cooperative in Portsmouth, NH. He offered an industry perspective of the impacts of the WGOMCA.

Is the Closure Meeting its Goals?

Kendall expressed the need to first identify the goals of the Closure. He believes that if the goals are to protect habitat, it works. If the goal is to reduce landings and protect fish stocks from commercial fishermen, it works. If the goal is to protect fish stocks from all fishing pressure, it does not work, as recreational fishermen are still allowed to fish within the Closure.

What is the Effect on the Fishing Community?

The WGOMCA has had a substantial impact on the Co-op. Prior to the Closure, 80% of the Co-op fleet fished in that area. After the Closure, people had to change where and how they fished. This impact has been felt by fishermen from Maine, Gloucester, Boston and Provincetown.

What can We Understand about the Closure?

The Closure has been intact for more than 10 years, and industry, managers and scientists still do not understand what the effects of the Closure have been. Kendall referred to Ray Grizzle's research, a project that he is an industry partner on, which is beginning to understand the "in versus out" effects of the Closure. He points out that the study area represents only a small portion of the WGOMCA though.

What Research needs to be Done?
Research within the Closure should continue. The current crisis in cooperative research funding will make the continuance of research difficult, but Kendall believes that more studies on biomass in the Closure are needed to better understand this management tool.

What does the Future hold? Should it stay Closed?
Groundfish management allows for only 46 days of fishing a year. With the passage of Framework 42, groundfish days count 2:1, leaving only 23 days to fish in a year. If the area was opened completely and there were no rolling closures, mortality would not be increased because of trip and DAS limitations.

Open access for all boats in the future would be ideal if the area no longer needs to be closed. Part of the Closure is deep water mud and not a critical groundfish habitat. It is, however, a refuge for shrimp. If a consistent, high quality shrimp product can be isolated by opening potential habitat, the mostly imported Northern shrimp market may be strengthened for U.S. fishermen and shoreside processors.

Question and Answer
There was an in-depth questions and answer session following Kendall's talk. It mainly focused on fine-tuning the Closure area to maximize the benefits to the region's ecology and to the fishing industry.

If you were the person in charge, how would you design the Closure? Kendall believes that if a closure is designed to help habitat, then a big closure with different sediment types is appropriate. If the goal is to reduce fishing mortality, areas of highest mortality should be chosen. He does not disagree with how the current boundaries were

chosen, but he questioned if it still needs to be closed with the other regulation restraints that fishermen currently have.

Along with other presenters at the symposium, Kendall stressed that the effects of the WGOMCA cannot be looked at singularly. Current regulations play a large part in the recovery of fish stocks. Regulations have continued for nine years. It would be difficult, if not impossible, to tease out individual management effects.

If there is a connection between habitat and juvenile groundfish development, would there be a way to balance access to particular grounds with habitat preservation? This could work by finding and protecting areas identified as critical juvenile fish habitat. But the key will be connecting the relationship between habitat and juvenile groundfish life history with empirical data from the industry.

The fleet could be spread out by fine-tuning the boundary lines of the WGOMCA. Opening the Closure does not necessarily result in access. DAS limitations would make it difficult for fishermen traveling long distances (>20 miles) to access the grounds and return to port.

Assigning specific habitat closure areas could be used to increase access by preventing bottom tending gear and allowing "soft-bottom" fishing such as gillnet or longline fisheries to occur.

Assessing Bottom Gear Impacts in the WGOMCA: A Multifaceted Approach

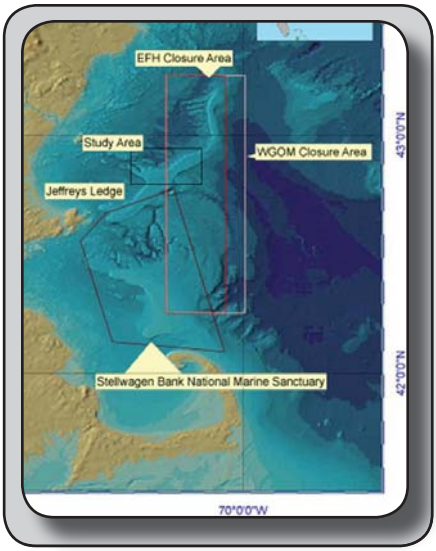
***Mashkoor Malik**, Graduate Student, and **Larry Mayer**, Director, UNH Center for Coastal and Ocean Mapping*

Mashkoor Malik presented the results of a UNH Center for Coastal and Ocean Mapping (CCOM) study of the seafloor of the WGOMCA.

Objectives

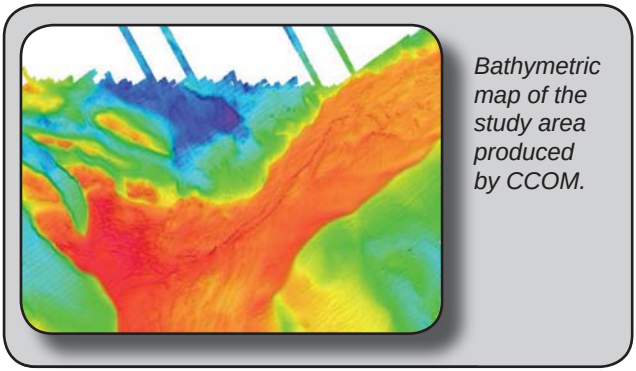
The objectives for the CCOM study were to:

- Construct a bathymetric map of Jeffrey's Ledge to serve as a framework for subsequent studies.
- Test the potential use of multibeam sonar to monitor fishing gear impacts.
- Determine if it is possible to observe closure impacts with multibeam sonar.



Summary of Results

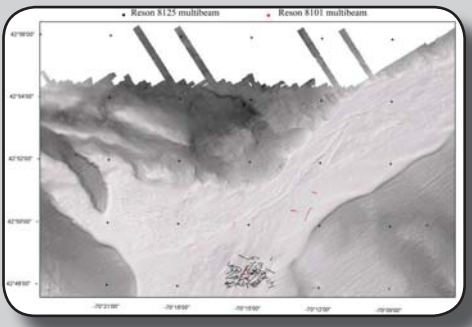
Video, sidescan sonar and multibeam sonar (MBES) were used to investigate the study site. A Reson 8101 MBES survey was conducted in December 2002-January 2003. It covered the middle of Jeffrey's Ledge with a total of 16.6 km x 24.6 km of area surveyed. It was used to create a high-resolution (~5m) bathymetric map, which was made available to UNH researchers for subsequent planning and research. The resolution was fine enough to see iceberg scours, sand waves, end moraine-like structures and bottom gear marks. Reson 8125 MBES (a higher frequency



Bathymetric map of the study area produced by CCOM.

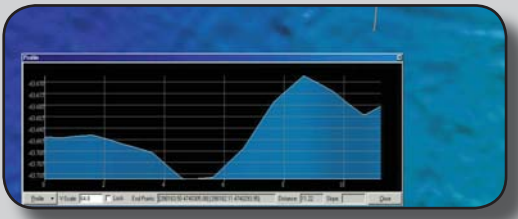
MBES) was used in 2003. It allowed enhanced resolution (up to one meter) covering a 2 x 3 km area in the middle of the study site. Both MBES surveys were conducted to provide coverage over both the open and closed areas in the western GOM. About 25 km of sidescan transects were collected in 2003 overlapping the previously collected MBES data. A bottom videographic survey of over 189 bottom sampling sites (collected by Larry Ward, UNH) was also analyzed during this study.

Amongst the widely known impacts of bottom-tending gear (i.e., scraping the seafloor, removing sessile epifauna and infauna, and leveling off features), MBES was used to successfully map the scraping impacts in the form of bottom marks. The analysis of high-resolution MBES data identified bathymetric scars that later were attributed to bottom-tending gear. The depth of these bottom marks was described as several cm deep with lengths up to several km. The widths of these marks were observed to be about 3-5 m and the marks did not show any strong directionality. Bottom marks were also detected using side scan sonar (2003, Klein 5500; 2004, Benthos 3D), but were not visible in the video data. The bottom marks were found on both the open and closed sides around the WGOMCA, and there was no difference in density inside versus outside the closed area. Indeed, some seabed marks were continuous across the open–closed boundary. The bottom marks are often, though not always, associated with boulders at one end and a depression at the other. Physical evidence (size, length, orientation, presence of single rather than double marks) sug-



Bathymetric map produced by CCOM of bottom marks observed in the study area.

gests that the marks were made by scallop or clam dredges. In those cases where a boulder was found at the end of the bottom mark, the cause may be related to the indirect interaction of dredges or trawls dragging the boulders. The bottom marks seen with the sonar systems were not discernible by inspection with a video camera. This implies that the marks were old enough for the textural contrast expected in fresh marks to have disappeared, perhaps as a consequence of re-colonization or sedimentation. This, along with the fact that there were no differences in the bottom marks re-surveyed more than one year apart, implies that the bottom marks may be long-lasting and/or created before the Closure.



Cross section of a bottom mark observed in the study area.

Cross section of bottom mark ending in a boulder.

During the course of the study, bottom-tending gear impacts resulting in a leveling of features (i.e., loss of habitat complexity) were also addressed. The video data were used to classify the video sites into one of the seven classes (e.g., flat mud and sand, mud and sand with biogenic structure). The underlying assumption of this model is that with increasing level of bottom fishing, the level of habitat complexity would be lost (e.g., biogenic structure like burrows would be leveled off converting a site described as mud and sand with biogenic structure to flat mud and sand). Although video data was able to differentiate between classifications, the complexity loss in each class has yet to be determined. Another critical concern is the potential resolution of the MBES whereby MBES is not expected to differentiate between features at scales of few cm (e.g., burrows, sponge cover, etc.). During this study, MBES derived classification maps were constructed with seven classes from video data (flat mud and sand 41.18%, biogenic structure 0%, shell aggregate 36.36%, pebble and cobble 32.43%, pebble and cobble with cover 41.67%, boulders or partially buried boulders 55.81%, and piled boulders 57.14%).

An ability to integrate and compare multi-beam sonar, sidescan-sonar and bottom-video data in a single, interactive, three-dimensional workspace greatly facilitated the analysis and interpretation of these complex data. The evidence collected during this study suggests that bottom fishing may cause long-term physical impacts on seafloor structure. Having now established a detailed, precisely positioned basemap of bottom marks, future work will continue to monitor the fate of these features and include additional work on Jeffrey's Ledge to map the distribution of demersal and benthic species. Comparison of these distributions with bottom-impact maps will inevitably result in a better understanding of long-term changes in benthic populations.

Efficacy of Fishery Closures in the Gulf of Maine

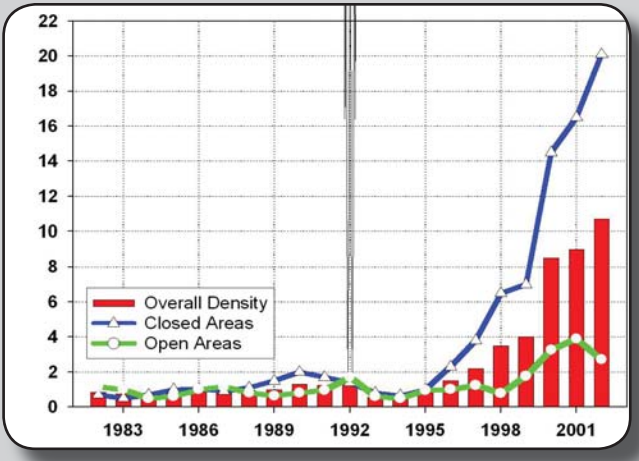
***Mike Fogarty**, Fisheries Biologist, NOAA Fisheries Northeast Fisheries Science Center*

Mike Fogarty presented an overview of the complexity of the closures in the Gulf of Maine and evidence for biomass increases, larval protection and other benefits to the ecosystem that closures have provided. The closures discussed were Closed Area I, located on Western Georges Bank; Closed Area II, located on Southeastern Georges Bank; and the WGOMCA.

Fishery closures are primary management tools used to manage New England groundfish stocks. Almost all of the GOM is subject to closure at some point during the year due to both rolling and year-round closures. Year-round closures currently cover 22,000 km^2 of seafloor.

Within-closure Effects

There has been a tremendous increase in the biomass of sea scallops on Georges Bank since closures were adopted there in 1995. In general, sedentary finfish species have seen greater rebounds in closed areas compared to more mobile fish, such as cod, which may only be present in the closed area for short periods of time. Species that ex-

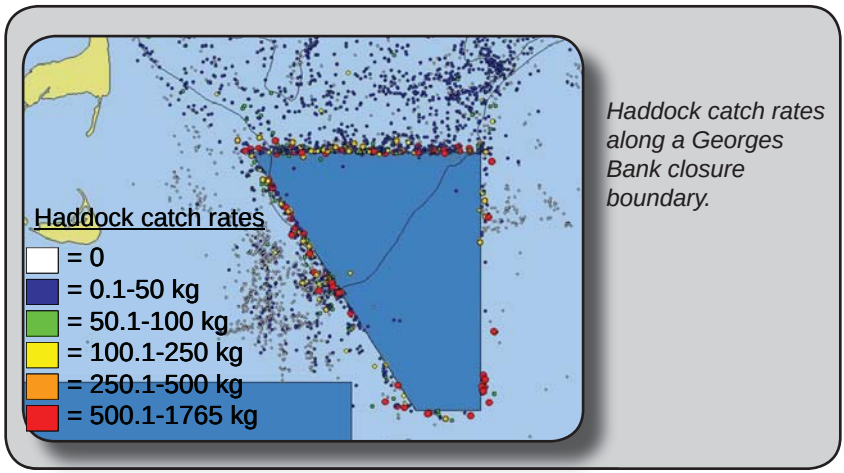


Within-closure effects on sea scallop density.

hibit intermediate movement patterns benefit from closures but also provide a benefit to the fishery by migrating out of closures.

Closure Spill-over Effects

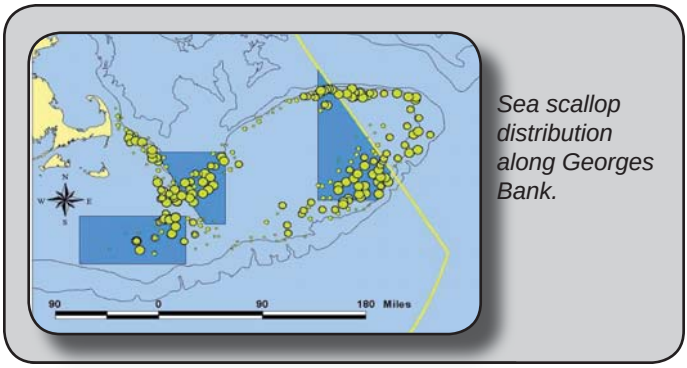
Open areas adjacent to closed areas have also experienced increases in fish abundance, due to the spill-over effect. Many fishermen experience economic benefits by "fishing the line." Catch rates of haddock



Haddock catch rates along a Georges Bank closure boundary.

and yellowtail and winter flounder are much higher along closure boundaries (e.g., adjacent to Closed Area I) than farther from closures due to spill-over. However, this is not the case for hake.

A model study on larval export showed that for both self-seeding and cross-seeding animals, larvae released in Closed Area I seeded areas outside of the closed area. However, adults in Closed Area II only tended to seed the closed area.

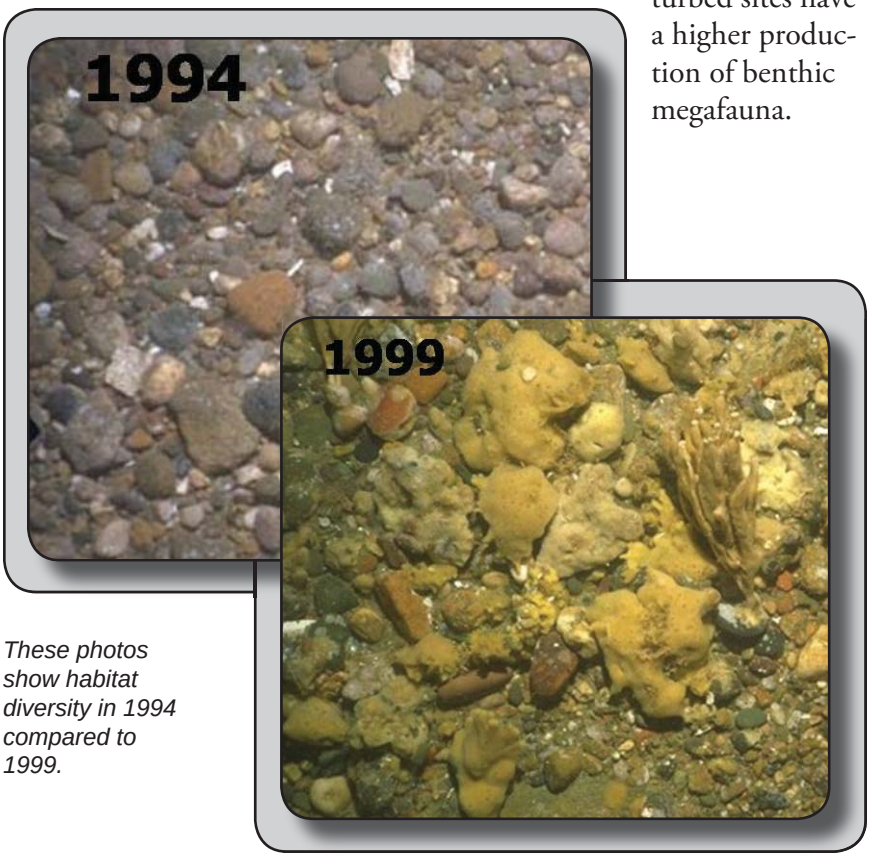


Sea scallop distribution along Georges Bank.

Other Ecosystem Considerations

The WGOMCA closed an area of high species diversity and fishing effort, displacing many fishermen. However, the abundance and biomass of fish has increased dramatically in closed areas and has correlated with a reduction in fish mortality. Maps of species diversity showing the species affected by trawling will be used to decide where to have future closed areas to protect biodiversity.

The recovery of gravel habitat epifauna is evident in photographs from 1994, 1995, 1996, 1997 and 1999. Also, the benthic megafauna has grown dramatically in undisturbed areas such as Georges Bank Closed Area II. In a comparison of shallow sites versus deep water sites, the benthic megafauna had a much greater increase in the undisturbed deep water sites than the shallow sites. Overall, undisturbed sites have a higher production of benthic megafauna.



These photos show habitat diversity in 1994 compared to 1999.

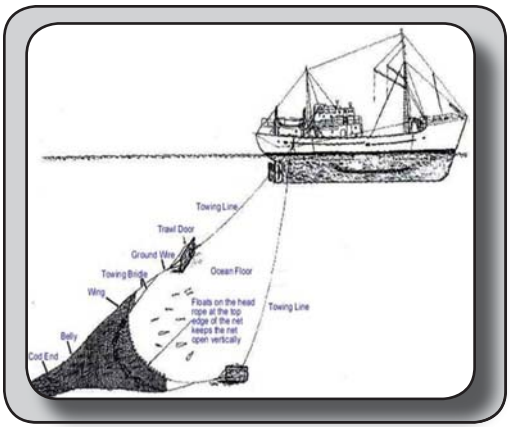
Is the Northern Section of the WGOMCA Important Habitat for Juvenile Groundfish?

Jonathan Grabowski, *Research Scientist, Gulf of Maine Research Institute*

Jonathan Grabowski presented results from cooperative research that assessed the importance of habitat for juvenile and adult groundfish (i.e., cod, haddock and goosefish).

Do Juveniles use Specific Habitats?

The first research project presented was conducted just off mid-coast Maine. Sidescan sonar combined with bottom trawl surveys (but not from rock habitat) showed that large juvenile cod are found far more in gravel habitat than in sand or mud. Young-of-the-year were found predominately in sand environments in shallow waters. This study also used video and hook-and-line sampling to investigate if juvenile cod use structured habitat and if this life-history stage is a potential limit to future production. The research implies that structured bottom is likely an essential fish habitat for juvenile cod over one year old. There will have to be more research done on the effects of these habitats on diet, growth and survivorship to ultimately determine if the success of large juveniles limits adult abundance and fishery productivity. Ignoring these complex habitats leads to an incomplete story.



Is the WGOMCA Important Habitat for Groundfish?

The second study was to see if closed areas in the Northwest Atlantic provide critical habitat for groundfish. The investigators hypothesized that groundfish abundance would be higher inside the WGOMCA and that juvenile groundfish would favor structured habitat for shelter, especially in untrawled reserves.

Trawl surveys in 2004-2005 were used to examine how the following factors influence the abundance, length, condition and diet of groundfish in the Gulf of Maine: season (spring vs. fall), reserve status (in vs. out), and habitat (mud vs. edge of cobble/ledge). Trawl surveys were conducted using a 54' trawler with a 5 cm cod end mesh and 15 minute tows at 2.3-2.5 knots.

The study found an effect of edge/mud inside the WGOMCA for Atlantic cod abundance, but not outside the Closure. For cod, a greater amount of juveniles and adults were found on the edge of the Closure and no habitat effect was observed outside the Closure. A greater abundance of haddock was found along the edge of cobble/ledge habitat than in the mud, but there was no effect of the Closure on haddock abundance. Haddock were larger outside the Closure in spring, but smaller outside the Closure in fall. For the goosefish, there were fewer juveniles inside the Closure and no habitat or closure effects for the adults.

How is the WGOMCA Affecting Groundfish?

The juvenile abundances inside the Closure were very low in 2004 and 2005. Juvenile goosefish were more common outside the WGOMCA, possibly a consequence of food availability.

What Research is needed to Evaluate the Closure?

Several avenues for research were suggested:

- Multi-year groundfish surveys to determine if abundance levels in the Closure in 2004 and 2005 were normal or anomalous and if habitat use is density dependent.
- Groundfish sampling in structured habitat.
- Stock structure of cod and other critical species.
- Determine important bottlenecks to the recovery and sustainability of populations.
- Integrating our understanding of how all closed areas work in concert.

Effects of Mobile Fishing Gear on Benthic Habitats

***Joseph DeAlteris**, Professor, University of Rhode Island Fisheries Center*

Joseph DeAlteris described the results of his recent research projects that compare benthic disturbance due to natural causes with fishing effects, the effects of 40 years of scientific trawling on the soft bottom habitats in Narragansett Bay, and an alternative paradigm for conserving fish habitat. On the first issue, he argued that the effect of fishing needs to be scaled against natural seabed disturbance in order to assess its effect on sediment. On the second issue he found that soft bottom habitat variability masked any trawling impacts, and on the third issue he proposes evaluating habitat based on vulnerability, risk and availability. His presentation synthesized the research and its applicability to the WGOMCA.

Effects of Fishing versus Natural Disturbance

The objectives for this study were to:

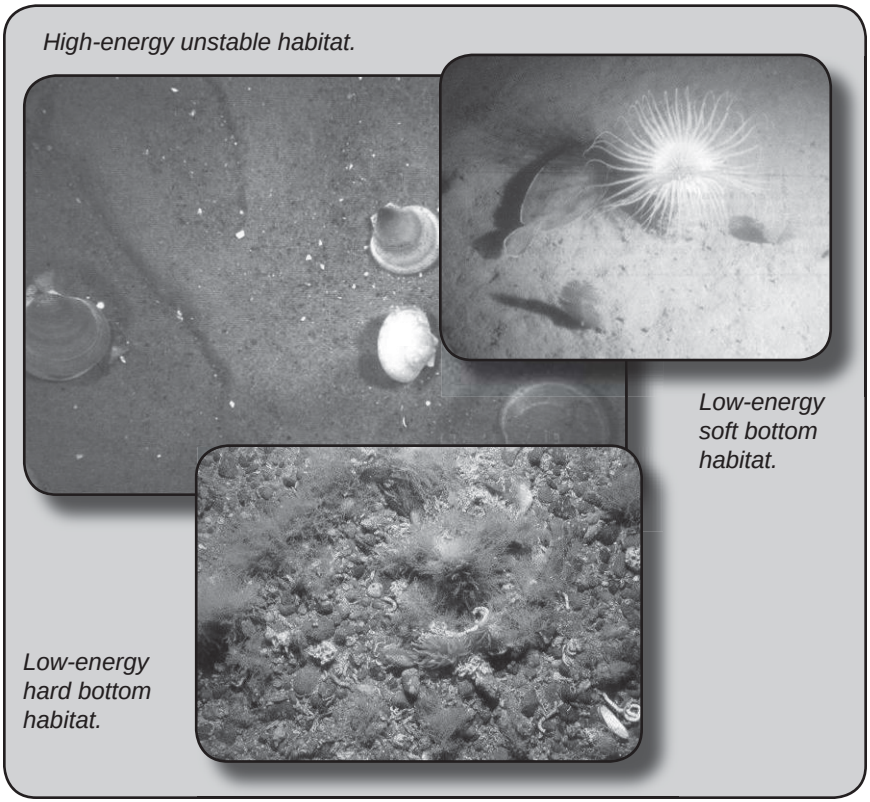
- Analyze seabed disturbance due to fishing by comparing sidescan sonar data for Narragansett Bay.
- Predict seabed disturbance due to natural causes at shallow sand and deep-mud experimental areas based on waves, current climates and sediment texture.
- Estimate the longevity of bottom scars in sand and mud bottoms.

When comparing the seabed habitat types related to substrate stability, there were three classified components: stable substrates, quasi-stable substrates and unstable substrates.

The sea bottom effects depend on the gear being towed, whether it is a bottom trawl, scallop dredge or hydraulic clam dredge. Some habitat disturbance effects of mobile fishing gear observed include:

- Re-suspension of fine sediments.
- Moved sediments creating burrows and smoothing natural bedforms.
- Turning over larger cobble boulders.
- Scraping sessile epi-benthic organisms off the substrate.
- Damaging or destroying smaller organisms in the surface sediments.

By definition, stable substrates are never disturbed by natural processes, so mobile gear contact is problematic. Stable substrates allow development of complex flora and fauna, so fishing gear has a more dramatic impact. The habitat is characterized by a long recovery time.



Unstable substrates are naturally disturbed, so fishing is not as problematic. The fauna and flora in unstable substrates are characterized by a relatively short recovery time. Mud scars will last over 60 days and sand scars last less than 48 hours. Thus, fishing appears to have a greater affect the more stable a substrate is. The effects of fishing on mud substrates may be problematic in some situations. Characteristics of seabed substrate could be used to determine the vulnerability of a substrate to fishing action.

Effects of Scientific Trawling on Soft Bottom Habitats in Narragansett Bay, RI

There is a stock abundance survey site in Narragansett Bay that has been trawled every week for 45 years and DeAlteris examined whether and how trawling had been affecting this sandy site. Data analysis revealed no major differences in species diversity, taxonomic distinctness and composition between impact and control areas, although the stations were not completely homogeneous. The natural variation of the benthic habitat exceeded the variation caused by trawling disturbance.

Alternative Paradigm for the Conservation of Fish Habitat

Georges Bank is regenerated by winter storm activity, with daily disturbances in shallow water and every three to six months in deeper water. On Georges Bank, an alternative paradigm for conservation of fish habitat was described. It was based on vulnerability, risk and availability. The vulnerability is based on frequency of disturbance by natural processes as an indicator of substrate stability. The risk of fishing disturbance is based on the frequency of disturbance by mobile fishing gear. The availability of habitat type is based on substrate type. The gravel habitat had the highest fishing disturbance. It was the most vulnerable, but the least available. Sand is most available, but the second most disturbed. Mud is the least disturbed and moderately available. Thus gravel habitat has highest need for protection.

Applicability to WGOMCA

The WGOMCA includes many substrate types. The URI research has shown that sand habitats are in less need of protection relative to

gravel. Based on that work, full recovery may have occurred on sand and mud substrates. Recovery might be slow but ongoing on rock-ledge and gravel-cobble substrates. The gravel-cobble and rock-ledge substrates are limited in availability and are certainly vulnerable to the effects of mobile fishing gear, but are not now at risk due to the existing closure. Such limited, hard-substrate habitats require continued protection.

Conclusions

All substrate types experience some mobile gear fishing impacts. It is speculated that full recovery has occurred on sand and mud substrates within the WGOMCA, but that recovery is slow and ongoing on rock-ledge and gravel-cobble substrates. The gravel-cobble and rock-ledge substrates are limited in availability and are vulnerable to the effects of mobile fishing gear, but are not now at risk due to the existing closure. The spatially limited hard substrate habitats are in need of continued protection.

Stable Isotopic Signatures in Catch Composition in Groundfishes Indicate Local Processes at Work in the WGOMCA

***Les Kaufman**, Professor, Boston University; **Elizabeth Soule** and **Briana Brown**, Graduate Students; and **Paul Vitale**, Commercial Fisherman, Gloucester, MA*

Briana Brown reported on the results of cooperative research by Les Kaufman, in partnership with the Massachusetts Fishermen's Partnership, the F/V Angela and Rose, and NOAA Fisheries. They conducted a study on trawl sampling for groundfish in multiple habitats, both inside and outside of the WGOMCA, within the sliver of overlap with the Stellwagen Bank National Marine Sanctuary (SBNMS). The project came about due to observations by fishermen of strong local effects associated with year-round and seasonal closures.

Study Objectives

This study compared trawls inside and outside of the WGOMCA within the SBNMS to see if there was a difference in catch and composition by species, size and the structure of the food web. The study

also assessed whether stable isotope analysis corroborated with acoustic telemetry observations of sedentary or home-ranging behavior in some cod and if stable isotopes could indicate food web parameters.

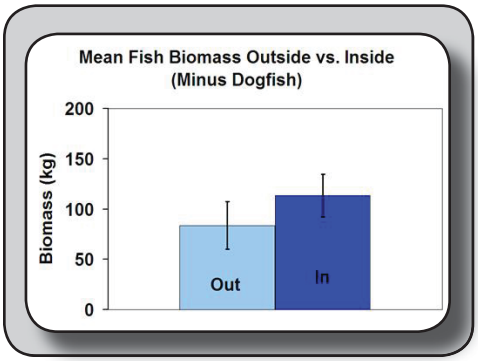
A Few Challenges

The project collected a lot of data to assess its primary questions, despite the following hurdles:

- There were many habitat types and areas to sample within short periods of time.
- Trawlable areas of a given habitat were not equally available inside vs. outside the Closure.
- Fish movement from season to season required additional sampling.
- There were trawling difficulties on boulder habitat.
- Trawling is generally not an effective way to answer fine-scale spatial questions.
- Trawl data was needed, but is counterproductive to resource conservation.

Results

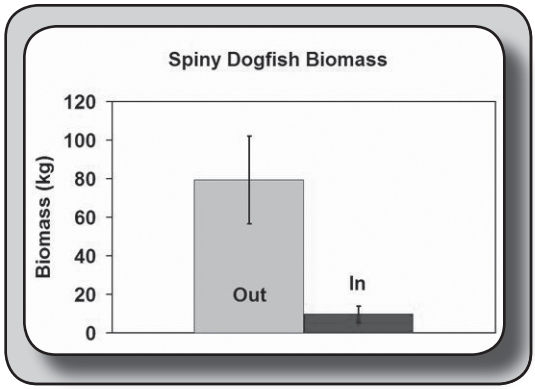
A factor analysis on abundance yielded two factors related to WGOMCA effects and seasonal effects. Haddock, witch flounder, red hake and dogfish had higher biomass inside the Closure. Other sand loving species such as longhorn sculpin, yellowtail flounder, winter flounder and sea raven had higher biomass outside. The species most abundant inside the Closure were common in the sliver of overlap. The species more abundant outside the closure can be found further west of the sliver.



Were the Results due to Closure Implementation?

Dogfish were much higher in biomass outside the Closure. Other fish were somewhat higher inside. One year after the establishment of the Closure, a NOAA Fisheries

WGOMCA trawl study indicated that dogfish had a greater abundance outside the Closure. In a different study held six to seven years post-closure, dogfish were more abundant inside. In fishermen's experiences, they are abundant and a nuisance.



Food Web Effects

The North Atlantic food web is very complex. Carbon (delC13) and nitrogen (delN15) signatures can be analyzed by measuring both stable isotope forms within fish musculature. These isotope levels differ predictably by how high a fish feeds within its food web. For example, apex predators would have relatively high delN15 compared to lower food web organisms such as phytoplankton. This information can also be used to analyze the diet of a fish for the past several weeks. Predators that feed on bottom organisms will have high delC13. The investigators determined that cod move up in the food web as they get larger. Predators feed at higher trophic levels inside the Closure, but only on hard bottom.

Eelpout were observed to stay at the same trophic level regardless of size. Young haddock feed on zooplankton whereas older haddock feed on benthic animals. Therefore, delC13 should be higher in adults. The investigators expected fish to feed higher in the food web inside the Closure, due to higher diversity of prey.

Conclusion

The WGOMCA does influence how fish feed, which means it is influencing their prey communities and how predators and prey interact. The trophic effects of the WGOMCA are species and habitat dependent. The food web is constantly reshaping over time. Despite the small size of the WGOMCA, it is altering diet, feeding behavior and food web relationships.

An Overview of the Seafloor Habitat Recovery and Monitoring Program (SHRMP) at Stellwagen Bank National Marine Sanctuary

***Peter Auster**, Science Director, National Undersea Research Center, University of Connecticut*

Peter Auster reported on a benthic study conducted within the Stellwagen Bank National Marine Sanctuary that compared sites inside and outside of the WGOMCA.

Objectives and Methods

The objectives for the study were to understand the role of spatial management measures for the conservation and sustainable use of biological diversity for:

- Habitat and microhabitat.
- Epifaunal communities.
- Infaunal communities.

Both still and video cameras were used to quantify the patterns of community composition, diversity and habitat variation.

Examples of seafloor communities.

Results

Several multivariate approaches (e.g., hierarchical cluster analysis) were used to identify similarities between the sampled habitats and their respective communities (e.g., epifaunal, infaunal and microhabitat features). Multivariate approaches are used for grouping objects of

similar kind into respective categories. In other words, this is an exploratory data analysis tool used to sort different objects into "groups" in a way that the degree of association between two or more samples (or grouped samples) is maximal if they belong to the same group, and minimal otherwise.

Between 1998 and 2005, the investigators observed a substantial change in community composition in several habitat types when sites inside and outside of the Closure were compared. For example, communities in boulder and gravel habitats both changed since the time of closure and along pathways that are separated by closure status (i.e., inside and outside communities differ). Comparisons of the abundances of species within functional groups (e.g., encrusting, erect, mobile, massive) using analysis of variance showed that all groups were significantly affected by substrate and year, but erect epifauna had a statiscally significant effect due to closure status. This is an important finding as erect fauna (e.g., branching sponges and other invertebrates) serve as habitat for small fishes and their prey.

Seafloor Succession

The data suggests that the WGOMCA is recovering (based on changes attributed to closure status), but does not indicate that the system is necessarily resilient (returning to a previous state). Managers expect that seafloor communities are successional in nature (like old farm fields returning to forest), but this is not always true. Some communities exhibit stochastic or nonlinear responses to disturbance. A random pattern of community dominance may occur such that beyond a threshold, a community will shift to another type and remain so even in the absence of disturbance. In other words, closing an area may not result in communities returning to a state that provides all of the ecological goods and services we expect. However, data from this study certainly demonstrates that recovery of seafloor communities increases functional groups of species that provide shelter value for fishes while not necessarily returning community composition to one that represents a "pre-fishing" state.

Summary and Conclusions

A significant portion of the symposium was dedicated to discussion of the issues raised by the presentations. Discussions took place after each presentation and at the end of the morning and afternoon sessions. The following is a summary of the major issues raised by attendees as they relate to the focus questions for the meeting.

Is the Closure Meeting its Goals?
From a regulatory perspective, the original goal of the Closure was to reduce cod landings. This was then expanded to include protection of essential fish habitat. However, it is difficult to analyze the specific effects of the WGOMCA due to the complex suite of management measures (rolling closures and changes in gear sizes) that have been in place at the same time. These measures collectively reduced mortality on GOM cod through 2002, but did not stop groundfish fishing altogether. Recreational fishing continues within the Closure and has resulted in a significant portion of the total cod landings.

From an industry perspective, many fishermen agree that there has been a visible increase in the number of cod, grey sole, haddock and other species since the implementation of the Closure. However, industry is quick to point out that these increases are not solely due to the closed area, but are due to the cumulative impact of various management measures.

What are the Effects of the Closure?
Socially, the cumulative effects of management measures have resulted in significant social and cultural changes to the traditional fishermen. These have included the crowding of remaining fishing grounds, conflicts between those fishing with different gear types, impacts on family and social cohesion, and fleet consolidation from small-vessel operators to joint ownership of multiple boats and permits.

Researchers have observed an increase in density, biomass and taxonomic richness in those habitats protected by the Closure compared to areas outside of the Closure. Much of the taxonomic increase has

been identified as encrusting and vertical epifaunal species. Even though differences in groundfish abundance caught inside versus outside the Closure have been observed, a definitive link between habitat recovery and fish stock recovery has not been made. This is largely due to the difficulty of isolating the impacts individual management actions have had since the Closure was established.

Spill-over effects, or increases in catch rates along the Closure boundary lines, have been experienced for haddock and yellowtail and winter flounder. This phenomenon is responsible for fishermen "fishing the line" for an economic benefit.

Tremendous increases in the biomass of sea scallops on Georges Bank have been observed since closures were adopted there. In general, sedentary finfish and shellfish have seen the greatest increases compared to more mobile species, such as cod, that may reside within the closed areas for only short periods of time.

How Far have We Come in Understanding the Closure?
After almost a decade of the WGOMCA, our understanding of the impact of loss of habitat complexity and of bottom tending fishing gear has significantly increased. Underwater video and sonar technologies have improved the ability to detect and map habitat complexity and geographic features have given the science and stakeholder communities access to high resolution maps that will increase our ability to identify essential fish habitats.

The impacts of bottom tending fishing gear on benthic habitat depends largely on bottom type and the gear being used. Stable habitats characterized by complex flora and fauna are at greatest risk of being impacted by fishing gear. These habitats include gravel and rocky substrates. Unstable habitats such as sand and mud are at the lowest risk of long-term impacts. Some researchers suggest that full recovery within the WGOMCA has occurred in sand and mud habitats, and that these habitats may be in less need of protection.

What Research is needed to Evaluate the Closure?

More research is needed to yield a better "before-and-after" picture of the Closure. Research is already being conducted with the cooperation of the fishing industry and should continue. More research is needed to better understand what areas should be protected and what areas could sustain catch. Examples include:

- The use of new tagging techniques.
- Groundfish sampling in structured habitat.
- Sonar and acoustic technologies to assess fish life stages.
- Characterization of larval dispersion.
- Better information on benthic habit types and where they occur.
- Documentation of spill-over effects.
- Continued evaluation of fishing gear impacts on habitat.
- Investigation of an ecosystem-based perspective on habitat that would include the entire water column and relate prey species to depth.
- Compiling data from several years is required to track eggs and larvae and to evaluate spill-over effects.

What does the Future hold for the Closure?

The collective opinion seemed to be in favor of a "finer tuned" closure area that would better protect habitat and the fishing industry. Amendment 16 to the Multispecies Fishery Management Plan is currently in process. Management intends to finish reviewing Amendment 16, scoping public comments and narrowing potential alternatives this year. Two such alternatives would move away from the DAS system. The amendment may move away from closures, especially the rolling closures and the WGOMCA. The final vote on Amendment 16 is anticipated for September 2008 and it will be implemented sometime in May 2009. The Omnibus Habitat Amendment will include habitat areas of particular concern (HAPC). HAPC may not necessarily change management measures, but the Jeffrey's Ledge-Stellwagen Bank HAPC will be considered.

This publication is made possible by the National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration grant NA060AR4170109 to the NH Sea Grant College Program.

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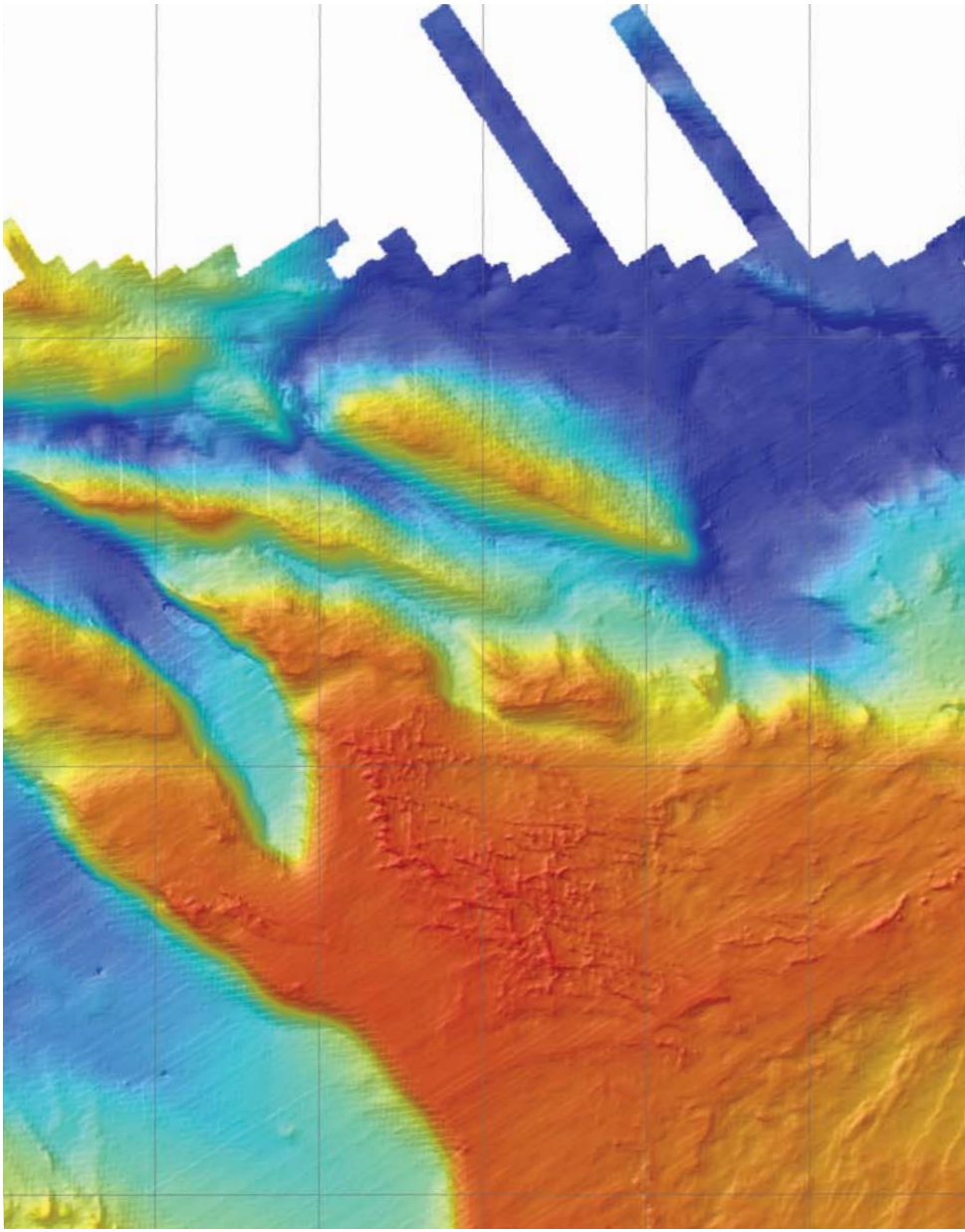

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