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Multispecies Coastal Shelf Recovery Plan: A Collaborative, Ecosystem-Based Approach

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Abstract.—This article explains the integration of an ecosystem into a collaborative management plan to restore New England's depleted multispecies groundfish stocks and decimated coastal fishery. Applying lessons learned from Maine's successful fishery for lobsters *Homarus americanus*, the Downeast Groundfish Initiative (an eclectic group of fishermen, scientists, and concerned individuals) created a new groundfish management approach designed to nest seamlessly within existing federal and state management systems and be compatible with a total allowable catch (TAC) approach, though it does not require TAC as the primary management tool. The plan resolves fine-scale issues affecting the fishery's biological productivity and addresses the economic, social, and cultural factors confronting fishing communities. The inadequacy of systemwide assessments in detecting local changes in marine ecosystems led to the creation of smaller, contiguous coastal shelf management units each of which encompasses the subpopulation of a key species such as Atlantic cod *Gadus morhua*. Each unit would have an inshore core layer encompassing the species' spawning grounds and nursery habitats while providing a limited, small-scale fishery for local fishermen using selective, habitat-friendly gear. A buffer layer outside the core area that brackets coastal shelf migration routes would also support a fishery using all legal gear types but with constraints, and an outer layer would provide a fishery operating under current federal regulations. The core and buffer areas would be collaboratively managed to enhance local stock recovery by local advisory councils of fishermen functioning under state administration and regional council oversight. The coastal shelf plan synchronizes the needs of coastal ecosystems and fishermen by restoring species diversity and protecting critical habitats while rebuilding commercial stocks. The approach can create robust, sustainable fisheries for all user groups, resolve equity issues among fishermen, and revitalize the economies of fishing communities of all sizes.

A major challenge facing fisheries managers has been how to establish an integrated management approach that simultaneously deals with both the ecological needs of depleted fish stocks and the economic needs of diverse stakeholders. The consequence of the failure to meet this challenge has been repeated cycles of economic dislocation, collapsed fish stocks, and degraded habitats. A corrective approach urged by Hilborn (2007) and others requires managers to "learn from successful fisheries that have been made sustainable." In accordance with that theme, the strategies that made one Gulf of Maine (GOM) fishery sustainable have been used to develop an alternative management approach for another that has been repeatedly depleted: New England's multispecies groundfish fishery.

The Multispecies Coastal Shelf Recovery Plan (MCSRP) has been designed to provide management capacity at multiple scales via a contiguous series of ecologically appropriate coastal shelf management subunits that nest within the federal fisheries management structure. The subunits would be organized internally to protect critical life stages and simultaneously provide equitable access for all user groups. The MCSRP incorporates many of the concepts developed for the Maine lobster *Homarus americanus* zones to address management problems that are similar to those in the multispecies fishery. The problems in the northeastern GOM (Figure 1) were taken as an example and a pilot project has been proposed to demonstrate and refine the plan's approach. While the MCSRP deals with the GOM, it offers a functional approach that could resolve similar management problems in coastal shelf ecosystems throughout the country. A brief review of the problems addressed by the MCSRP is followed by a case study of the Maine lobster zone, a discussion as to how those concepts can be adapted to a multispecies fishery, and a description of the MCSRP proposal.

Fisheries Management in New England

The agreement between the United States and Canada to subdivide the GOM by a boundary line (the Hague Line) came into effect on October 12, 1984 (IJC 1984). The agreement gave management authority over the western GOM to the United States and

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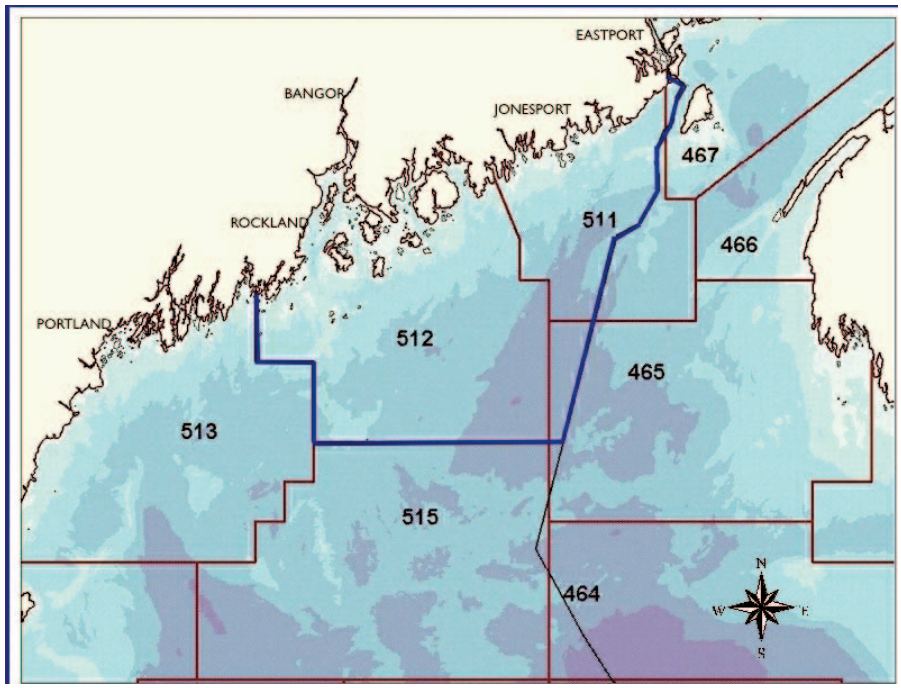

FIGURE 1.—Map of the Gulf of Maine showing the existing North Atlantic Fisheries Organization management areas (numbered) and the proposed pilot project area (blue boundary).

simultaneously required the U.S. offshore groundfish fleet operating in Canadian waters to return U.S. waters. The addition of these highly efficient offshore vessels to the existing New England groundfish fleet was accompanied by the rapid depletion of New England's coastal stocks (NOAA 1996). As there were few fish to catch, federal managers launched a series of amendments to the regional groundfish plan. These included adopting the current days-at-sea approach to restrict vessel fishing time, initiating a New England–wide vessel buyout, launching a regional training program that gave fishermen free training to prepare them for other industries in exchange for their permits, and a management plan designed to eliminate or degrade unused fisheries permits. Still, the result was extensive numbers of local depletions, along with the elimination of many coastal fishermen and fishery-associated economic activities. In retrospect, the size of fishing vessels, the size and numbers of nets allowed, and the use of new technologies were not adequately addressed.

Current Status of the Fishery

While partial recoveries have occurred in the western GOM and on the western Nova Scotia coastal shelf, groundfish stocks in the approximately 8,000 km^2 of the northeastern GOM between the two are arguably in worse shape today than when the Magnuson–Stevens Act was passed in 1976 (Sosebee and Cadrin 2006). Commercial quantities of important groundfish species were disappearing from much of the northeastern coastal shelf by the late 1980s (Census of Marine Life 2009; author's observations). There has been minimal recovery in the area, as indicated by the absence of commercial fishing activity and seasonal trawl surveys during the past 14 years (NOAA–Fisheries 1995–2009). However, small numbers of juvenile Atlantic cod *Gadus morhua*, pollock *Pollachius virens*, and winter flounder *Pseudopleuronectes americanus* have been reported in some areas, suggesting that a recovery based on local reproduction or eggs and larvae from the Bay of Fundy is under way.

Depletion Costs

The prolonged depletion of multispecies groundfish in the northeastern GOM triggered a predictable chain of events and escalating costs that has besieged eastern GOM fishing communities and fishermen. A coastal economy based on multifishery boats averaging less than approximately 14 m in length that only operated during fair-weather months has unintentionally led to the blanket elimination of all multispecies fishermen along the eastern 200 km of the U.S. coast. While about 20 federal permits remain, there are no active groundfishermen in the area. Their permits do not

confer enough "rights to fish" (expressed as days at sea) to enable them to participate in the fishery and effectively bar them from the fishery altogether (National Marine Fisheries Service [NMFS], Gloucester, Massachusetts, personal communication). Coastal communities have lost infrastructure, experienced damage to their economic, social, and cultural institutions, and lost access to other local fisheries with no process in place to ensure future access for their fishermen or justify local restoration efforts (Hannesey and Healey 2000).

Management Response

To date, little has been done to restore collapsed stocks in the area, even though it has a rich history with abundant landings of cod, haddock *Melanogrammus aeglefinus*, Atlantic halibut *Hippoglossus hippoglossus*, and other groundfish species (Goode 1888; Rich 1929; Alexander et al. 2009). The few protective regulations and spawning closures applicable to the depleted coastal shelf from Penobscot Bay east to Canada have proved to be inadequate. Unlike on western New England's coastal shelf, there has been no multispecies stock recovery in the eastern third of the coastal shelf since its collapse in the early 1990s.

Even though seasonal groundfish surveys by the NMFS indicate that the multispecies stocks in the northeastern GOM are still in poor condition (NMFS 2009), federal managers cannot confirm their depletion because there are insufficient data with which to evaluate these stocks separately. The data derived from the NMFS trawl surveys are reportedly weaker than those for other parts of New England because the nature of the coastal shelf bottom makes otter trawling difficult (NMFS 2009). To further complicate management's dilemma, there is so little fishing activity in the area that vessel trip report and Vessel Monitoring System data provides insignificant fishery-dependent information. Federal managers have assumed that the 8,000-km^2 area's prolonged depletion is either a local event (and expect stocks to eventually recover via groundfish populations moving into the area) or that it is due to climate change.

Summarizing the Problem

Since the passage of the Magnuson–Stevens Act in 1976 (Magnuson–Stevens Act of 1976), U.S. fisheries managers have estimated the populations of the 15 groundfish stocks throughout their ranges based on the assumption that they are pandemic populations. New England groundfish assessments are considered to be among the best in the world (Quin 1998). Yet despite the 50-year time series and rigorous reviews of the systemwide assessments, the current approach has not provided management enough guidance to restore this large area, neither eliminating overfishing nor achieving sustainability. In particular, the systemwide estimates do not provide federal managers the information needed to resolve several persistent problems linked to their inability to assess stocks at more local scales. There are at least six such problems:

1. Achieving sustainable fisheries requires a more holistic approach to the entire suite of factors involved, including population structure, life stage bottlenecks, forage species, and habitats. This requires a management strategy that is capable of functioning at multiple scales.

2. Local depletions often reflect the collapse of discrete population components that are undetectable until a number of them have accrued to create a large-scale depletion. It is unlikely that this cycle can be changed without addressing the depletions at a more local scale.

3. Some areas are more productive than others. The inability to monitor the GOM at multiple scales prevents management from matching the productivity of a given area's spawning components with removal rates by the fishery.

4. Reversing a declining trend in a stock requires that local depletions be detected quickly enough to protect the broodstock, juveniles, and habitats, a capacity that federal managers currently lack.

5. Access to the fishery is inequitable. Small and midsize vessels are unable to fish profitably or safely far from their home ports; thus, when fish disappear from an area for several years, local fishermen are forced out of business. Local depletions, combined with federal efforts to reduce access to the multispecies fishery, have caused a disproportionately large number of small coastal shelf fishermen to lose access. This has occurred throughout New England since the 1990s to the detriment of many fishing communities, though nowhere as much as in Maine.

6. The current pattern of decades-long local depletions punctuated by a few years of good harvests is extremely inefficient, economically disruptive, and ecologically untenable. This pattern has been repeated in the GOM at least three times since World War II and points to an ineffective approach to managing renewable resources that has seriously damaged the economies of coastal areas.

Constraints on Recovery

Comments from fishermen and community members throughout northern New England from 1998 to the present indicate that they perceive the loss of access to

the fishery as an unjust taking. They continue to question why federal managers have not designed rebuilding strategies for local fisheries or planned a redistribution of access linked to future recoveries in local areas. Resolving these inequities would do much to redeem the credibility of New England's federal fisheries management program.

That said, managing the myriad fine-scale events that affect stock abundance poses a dilemma for managers. The current system is based on systemwide assessments. These give valuable information about stock totals but not about the individual stock components or the factors affecting their abundance (GARM 2008). Local stock depletions are not detected until the estimate of total biomass falls outside the confidence limits for the entire stock assessment. This limitation is inherent in the assessment procedure and explains why local depletions have repeatedly been able to cascade into widespread stock collapses (Walters et al. 2004).

A growing body of research supports dealing with such issues by addressing them at multiple scales. The documented habitat preferences of several groundfish species give valuable insights into local behavior and distribution patterns (Methratta and Link 2007), while the relationship of diadromous species to various marine fisheries noted a century ago by Baird (1883) is being revisited. Indications of homing behavior by Atlantic cod in Ipswich Bay, Massachusetts (Groeger et al. 2007) support comparable work pointing to localized cod populations (Wroblewski 1998). Comparison of historical cod spawning sites with recent egg distribution patterns revealed that cod spawning areas have been in continuous use for nearly a century (Berrien and Sibunka 1999; Ames 2004). Tagging studies conducted by the Gulf of Maine Research Institute (Tallock 2007) have verified that the migration paths in the eastern and western GOM identified earlier (Perkins et al. 1997; Ames 2004) were still active. However, there were few returns from management areas 511 and 512 (Figures 1, 2) and no indication of the cross-boundary stock component identified by Hunt et al. (1998) in area 511 10 years earlier. Spawning activity had been noted in the area until the late 1980s (Berrien and Sibunka 1999) but disappeared entirely after the fishery collapsed. This was followed by more than a decade of NMFS groundfish surveys showing minimal numbers of cod in the area and the absence of commercial activity. Both areas once supported significant landings (Goode 1884; Rich 1929). In light of these results, it seems clear that one or more components of the GOM Atlantic cod population noted by Ames (2004) collapsed and has yet to recover.

A recent review of population substructures, spatial complexity, and the scale of management (Cadrin and Secor 2008) discusses the need for addressing such factors in management strategies. Spatial complexity is important because the multispecies stocks that coexist with Atlantic cod (Rich 1929) are also reported to exhibit similar local behavior (Bigelow and Schroeder 1953; Collette and Klein-MacFee 2002). These species include haddock, cusk *Brosme brosme*, pollock, white hake *Urophycis tenuis*, Atlantic wolffish *Anarhichas lupis*, witchflounder *Glyptocephalus cynoglossus*, American plaice *Hippoglossoides platessoides*, and winter flounder and were noted for their limited seasonal movements.

To test these reports, the seasonal movements of species described by Rich (1929) were evaluated and compared with those of Atlantic cod from the same period. Although the historical data were limited, they clearly showed that the seasonal movements of haddock were more limited than those of cod (Figure 3), that cusk remained close to a specific ground, and that white hake moved about the same distance as cod each season but remained on muddy bottom. Like cod, these species had slow recovery rates between areas when they were overfished, which suggests that they too were composed of smaller population units. This implies the need to conserve within-species diversity in order to maintain total stock abundance. Developing management capacity at smaller scales would thus appear to be important in avoiding the future collapse of these stock components. However, it also creates a unique opportunity for management. Because several multispecies stocks have components that remain in the areas historically occupied by subpopulations of Atlantic cod, these areas are ecologically appropriate for simultaneously managing the components of several such stocks at a smaller scale. Creating management units that bracket these areas would allow each to be managed more holistically and sustainably. As it happens, two existing management areas (511 and 512) would function very well as management subunits at this scale with but minor adjustments (Figure 4).

The Maine Lobster Fishery: A Successful Example

One particularly successful example of such a strategy can be found in a New England fishery that collapsed earlier, was successfully restored, and today provides one of New England's largest sustainable fisheries (Acheson 1988, 2000). The Maine lobster plan has evolved from humble beginnings into a multilayered management approach that has functioned well for more than a decade. It has minimal data requirements, entails minimal costs for management, and integrates well with federal and regional manage-

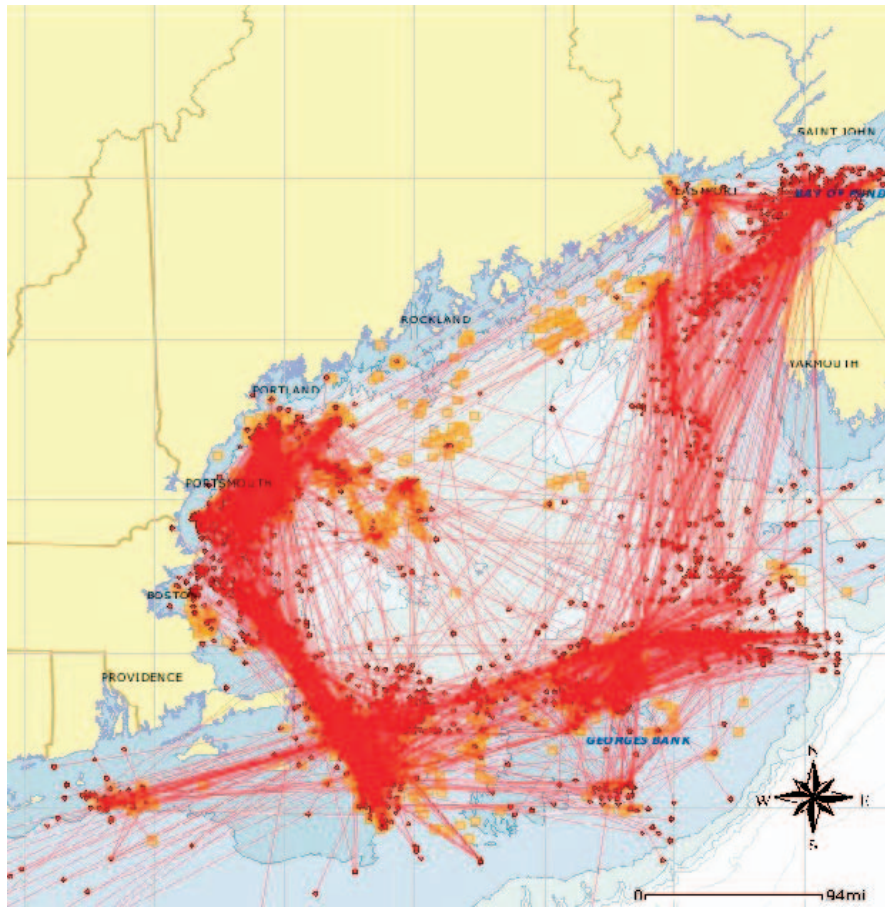

FIGURE 2.—Tagged releases (yellow) and recaptures (red) of Atlantic cod in the northeast regional cod tagging program. The absence of returns from north of Boothbay Harbor, Maine (about one-third of the way up the coast), suggests that two subpopulations became depleted or collapsed after 1985.

ment programs. The program has addressed the life stage bottlenecks of lobsters to create a robust, sustainable fishery and controlled access so as to benefit all user groups. While the lobster zone approach is not a panacea, it offers a more productive and less abrasive process for the various multispecies fishery user groups than the current approach.

For decades Maine's lobster fishery has supported approximately 6,500 licensed boats employing about 14,000 fishermen, and it is among the largest of the remaining commercial fisheries in New England. It is also arguably among the most robust fisheries, with landings of 30,000–35,000 tons per year and an exvessel value of approximately US$250 million.

Maine's collaborative area management plan is based on a few ecologically sound regulations governing the scale of fishing, mobility, and the types and amounts of gear fished. When technology threatened to overwhelm the fishery in 1997, regulations were passed that subdivided the state's coastline into seven ecologically discrete areas, or zones. Over time, three spatial layers were developed for the fishery, the core layer being the most restricted, the middle layer (managed by the Atlantic States Marine Fisheries Commission [ASMFC]) having fewer restrictions, and the offshore layer being under federal management. Today, Maine's Department of Marine Resources (DMR) oversees a collaborative management arrangement based on area advisory councils of local elected fishermen who recommend and review potential regulations. The area councils are also empowered to reduce the maximum number of traps.

The rate of entry into a zone is controlled by means of an apprentice plan that insures continued local access; effort is controlled by a trap limit, and mobility is reduced by requiring fishermen to keep at least one-

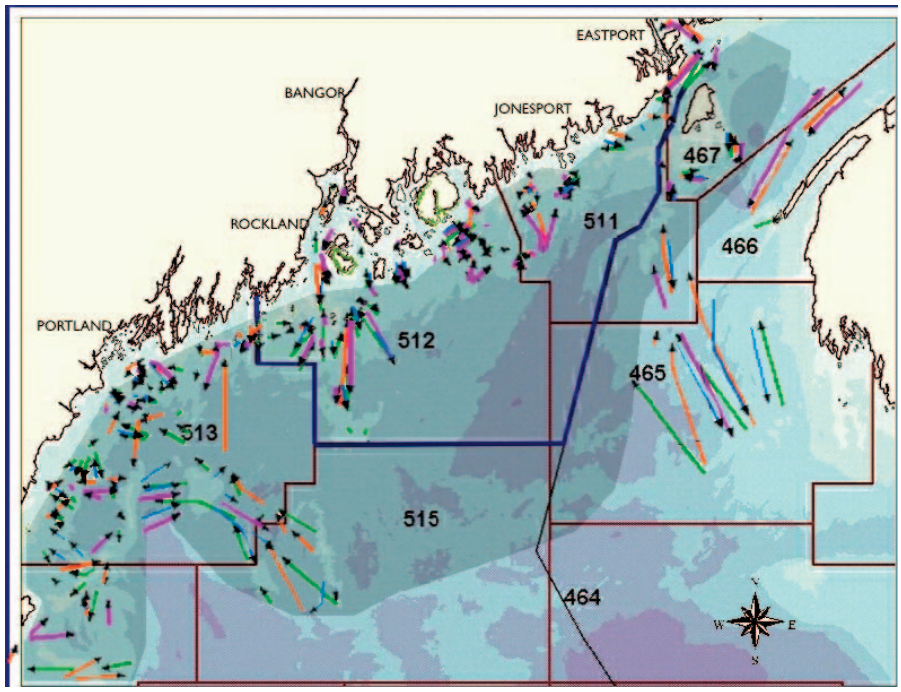

FIGURE 3.—Historical movements of haddock in relation to those of Atlantic cod in the northern Gulf of Maine. Shading indicates the area historically occupied by cod subpopulations; the arrows indicate the directions of seasonal haddock movements (blue = winter, green = spring, purple = summer, and orange = fall). Haddock and several other species stayed within the area occupied by a cod subpopulation throughout the year.

half of their traps in the zone in which they are based. An owner–operator provision has stimulated widespread stewardship among fishermen, and after a full decade of operation, the plan enjoys the support of Maine fishermen and coastal communities. The plan appears to have solved many of the problems that confronted the multispecies fishery, including the decline in local productivity.

History

Maine's lobster fishery was not always so robust. The fishery collapsed in the early 1930s, the victim of overharvesting and an aggressive canning industry that processed all sizes of lobsters. The collapse triggered the adoption of a unique management plan based on a small number of ecologically sound regulations, including many of those first proposed by Herrick (1911), that were incrementally introduced to the fishery over the following decade. These included protecting gravid females, protecting all juveniles and large adults, and limiting habitat damage and bycatch with a traps-only provision. By the 1950s the fishery had recovered enough to provide annual landings in excess of approximately 10 million kg.

By the 1980s, new technology (electronics, hydraulics, and wire traps) had been introduced into the fishery and landings had expanded dramatically. There were also concerns that these technologies would trigger extensive consolidation in the highly competitive lobster fishery and threaten the economy of Maine's many coastal communities. Some of the traditional restrictions on the fishery that had protected small, family-based lobstermen (such as territoriality) were being overwhelmed by the sheer number of traps being fished and the unexplained growth of the lobster population. Lobstermen could also see that the reasonable limits they had traditionally adhered to had benefitted them all. That awareness, combined with traditional methods of limiting their numbers, had reinforced stewardship on the part of fisherman and their willingness to find local solutions.

Institutional Arrangements

In 1997 the Maine legislature, working with the commissioner of DMR and members of the lobster fishery, developed legislation to preserve the informal management structure. Later, a committee of fishermen, managers, and academics convened by the commissioner developed specific regulations to put the approach into practice. Thus, codification of a

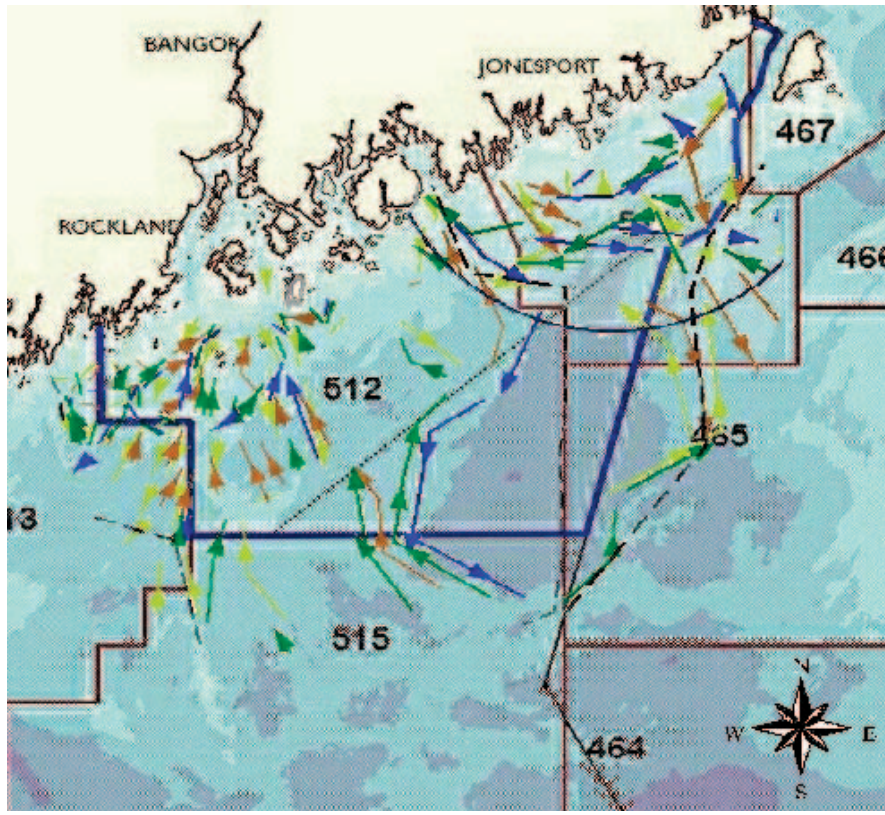

FIGURE 4.—Seasonal movements of Atlantic cod indicating that minor boundary changes to areas 511 and 512 would entirely enclose a subpopulation of cod and the spawning components of several other multispecies stocks. The arrows indicate the directions of the seasonal movements (blue = winter, green = spring, yellow = summer, and brown = fall).

traditional management approach provided a practical model for managing complex marine systems on the coastal shelf.

The Maine coast was divided into seven areas of approximately 1,000 lobstermen, each with an area advisory council of elected lobstermen from the area (Figure 5). Mobility was constrained by requiring lobstermen to fish at least one-half of their traps in the declared zone, and the scale of the fishery was controlled by means of a trap limit. Local access was protected by requiring "sweat equity" from applicants through a 2-year apprentice program that also controlled entry rates as well as an owner–operator provision that gave responsibility directly to the fisherman rather than the vessel (Acheson et al. 2000). These measures furthered Maine's original ecosystem-based approach by preserving the local nature of the fishery, controlling its scale, and enhancing the state's ability to continue managing without intensive data collection or landing limits.

The seven areas, or "lobster zones," were selected according to their ecological character and common fishing practices. The zones were further subdivided into districts, each community being allowed to elect one fisherman representative for each 100 lobstermen residing there. Even though communities often had several lobster gangs, in practice each district became the basis for community-based management whereby each town had at least one local fisherman on the zone council. The zone councils were granted authority to make some local regulatory changes, such as setting limits on the number of traps below the statewide cap, adjusting the length of the fishing day, and adding requirements to the apprentice plan to further control the rate of entry. Such changes require a two-thirds vote by the zone council before being forwarded to the commissioner for expedited rulemaking.

Originally, Maine regulations only applied to state waters (4.5 km from shore), but concerns about the fishery within Maine and by the ASMFC led to an expansion of their reach. Large-broodstock lobsters (which are illegal to land in Maine and are released

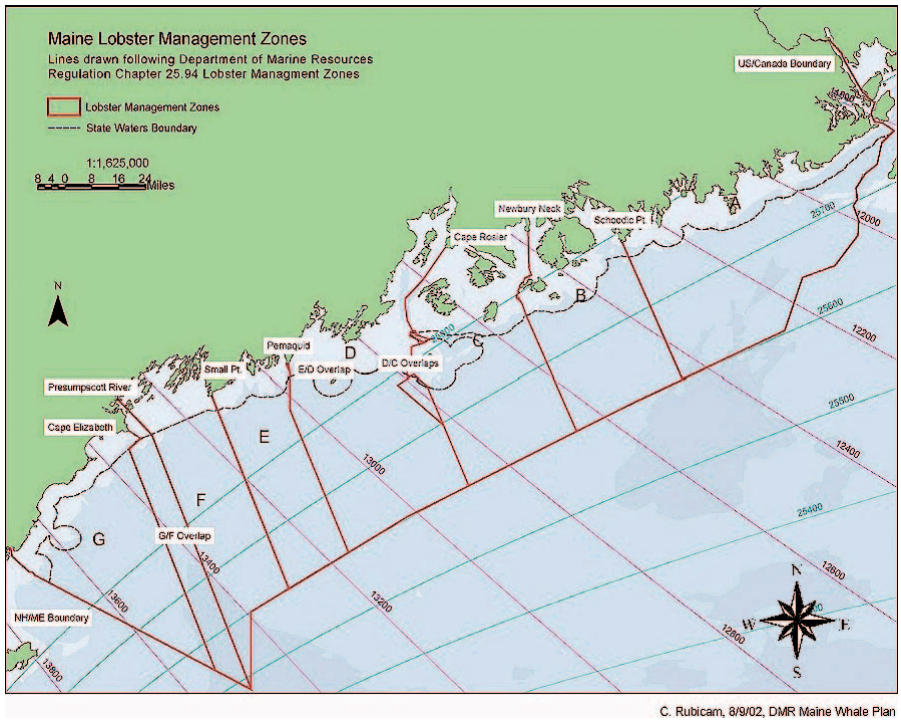

FIGURE 5.—Lobster zones designated by the Maine Department of Marine Resources.

unharmed by local fishermen) were being targeted by unprecedented numbers of vessels operating just outside state waters and being sold in other states. This was seriously undermining the willingness of Maine fishermen to continue with their plan. In response, the ASMFC designed a second management layer that extended state regulations and trap limits out to 45 km; this applied to all state vessels with federal permits. A third, outermost layer covering the rest of the GOM operates under federal regulations developed within the ASMFC that require trip limits for trawlers and allow additional traps to be fished. Today, all management areas in state waters have high landings and exhibit a somewhat skewed but intact population profile.

Reasons for Success

Combined with carefully chosen management subunits, the rigorous, ecologically sound regulations imposed on the lobster fishery within Maine waters have succeeded in giving lobsters the opportunity to reproduce, protecting juveniles until they recruit into the fishery, and protecting the habitats needed for survival—the three factors most important to a fishery's productivity. The plan has simultaneously provided thousands of coastal fishing families with a sustainable fishery close to shore, giving future generations the opportunity to participate in a productive, small-scale coastal fishery.

The criteria used to manage the inner lobster zone relate directly to the lobster fishery's productivity, that is, to the protection of broodstock, reproduction, juveniles, and habitats by limiting the fishery to traps. The middle layer is managed collectively by the ASMFC and the NMFS; management includes a mixture of controls whereby Maine fishermen must comply with state regulations and have federal permits as well. The outermost layer relies exclusively on federal regulations that provide nontrap fisheries with bycatch allowances and allows offshore lobstermen to use additional traps. The data requirements for maintaining the fishery continue to be minimal.

The key management innovations by the state centered on creating contiguous management subunits throughout state waters to deal with fine-scale ecological issues by (1) limiting habitat damage and technology through a traps-only provision, (2) limiting scale through controls on the number of traps, (3) reducing mobility by requiring that at least 50% of individual effort be in the declared zone, (4) instituting a state-mandated apprentice plan as the sole means of entry, and (5) implementing an owner–operator provision within state waters to enhance stewardship.

Access to a zone is controlled by the completion of the zone's apprentice plan and approval by the elected state lobster zone council. The management issues before the council specifically relate to the smaller, contiguous management units, their interactions, and local decisions on gear limits. Because of these constraints, fishermen are confronted with the choice of either nurturing local stocks to maximize their productivity or overfishing them and forcing themselves out of business. The presence of locally elected zone councils functions to further constrain the fishery.

Lobstermen initially considered the need to rely primarily on their local fishery to be a disadvantage. However, most quickly realized that if they improved the fishery the increase in the abundance of lobsters in their declared area meant that they would have larger landings. They began viewing ecological issues differently. Scientists became potential allies in developing ways to increase the number of lobsters and improve their fishery. Protecting broodstock, habitat, and juvenile lobsters in their zone meant potentially bigger incomes for themselves and their families in the future, even though their neighbors would also benefit. Management had created the conditions for stewardship to be expressed. The end result is a fishery so robust that it has defied predictions of collapse for decades.

The success of the lobster zone plan is based on a governance structure similar to that long used in New England: having relatively exclusive, multiple layers of management with nested management units mirrors the hierarchical structure of town, county, and state governance. Participants have responsibilities and constraints at their respective levels and function in collaboration with the management systems of the state, the New England states system (ASMFC), and NOAA–Fisheries.

The benefits of this approach are numerous, the most obvious being that it has created a sustainable coastal fishery in which most of the lobsters caught in the GOM are caught within Maine's 4.5-km territorial limit by several thousand participants. The dramatic recovery of lobster stocks in the narrow innermost lobster zones occurred decades ago, when lobsters outside of state waters were being exposed to the same environmental and anthropogenic factors that were degrading other coastal shelf fisheries. In spite of intense fishing pressure along Maine's territorial boundary, lobster landings have continued to be robust.

Management of Lobsters and Multispecies Groundfish

When the provisions of Maine's lobster management plan are compared with those of the federal multispecies groundfish plan, it becomes clear that the federal approach ignores important ecological, social, and cultural relationships (Table 1). Maine's lobster management plan has generally been supported by fishermen, and this is largely due to the safeguards used by the state to preserve those relationships in the fishery. By contrast, the federal multispecies fishery appears to be trapped in a series of destructive boom-and-bust cycles. Many factors are involved, but one obvious difference is Maine's multilayered approach, which operates at three different scales based on seven contiguous, ecologically distinct lobster zones through rigorous, habitat-friendly regulations that have kept fishing technology, mobility, and effort at sustainable levels.

TABLE 1.—Comparison of lobster and groundfish management strategies on Maine's coastal shelf.

Strategy	Lobster	Groundfish
Protect spawning	Yes	Marginal
Protect juveniles	Yes	Marginal
Protect habitat	Yes	No
Control scale	Yes	No
Control mobility	Yes	No
Control technology	Yes	No

While the validity of comparing two disparate fisheries can be disputed, there is no question that the large-scale, single-species approach taken toward the groundfish fishery would benefit from dealing effectively with issues of scale. The contrast between the lobster and groundfish fisheries suggests the importance of the following principles, outlined by Wilson (2006): (1) participation builds trust and shared understanding that enable fishermen to mobilize and self-organize; (2) multilayered institutions improve the fit between knowledge, action, and social–ecological contexts and lead to more effective responses at appropriate levels; and (3) accountable authorities pursuing just distributions of benefits and risks enhance the adaptive capacity of vulnerable groups and society as a whole. The successful management of the lobster fishery provides valuable new tools that are compatible with the current federal multispecies management plan, are appropriate for restoring other coastal shelf species and fisheries and have been very economical.

Ecosystem-Based Management: Advantages and Disadvantages

Before revising the management of the groundfish fishery, however, there are important issues to consider. One is whether the current large lobster population is mainly the result of eliminating most of the lobster's predators by overfishing groundfish

species rather than implementing the management plan. Predation is clearly a factor. It undoubtedly would be greatest in a system with only lobsters and groundfish, but the current ecosystem is far more complex. With an abundance of other prey available, such as Atlantic herring *Clupea harengus* and river herring (alewife *Alosa pseudoharengus*, American shad *A. sapidissima*, and blueback herring *A. aestivalis*) Atlantic cod would be less likely to target lobsters (Collette and Klein-MacPhee 2002). Evidence suggests that this was the case during the early colonial period, when herring were very abundant and before cod stocks were heavily exploited. Numerous reports since the 1600s note the great abundance of lobsters, and some even complain about the strong odor emanating from the windrows of dead lobsters that washed up on Cape Cod after strong easterly gales (Herrick 1896). It is also of note that the stomachs of cod from Eastport, Maine, in the 1890s were found to contain many crabs, mollusks, and fish but no lobsters at all (Kendall 1896). During the same period, lobsters were so common that they could be gathered from under rockweed, such as knotted wrack *Ascophyllum nodosum*, at low tide. The Atlantic cod of the period appear to have been opportunistic predators feeding primarily on fish and crabs. Lobsters and cod apparently coexisted quite comfortably at high population levels when the cod's preferred prey species were abundant.

One may also ask whether the approach taken to manage a single crustacean species such as the lobster would succeed with a suite of finfish species with markedly different ecological requirements and behavior. There are reasons to believe that it can, especially where depletions are related to overfishing and damaged habitat. However, the shift will probably involve a series of collaborative adjustments that gradually evolve among managers and stakeholders (Murawski 2007). If properly designed, regulations that protect the habitat, juveniles, and reproduction of one species can simultaneously protect those of several other species. For example, the historical spawning grounds and nursery areas of many Gulf of Maine groundfish stocks are within 25 km of the shore (Ames 1997; Berrien and Sibunka 1999) and could be managed more effectively under a layered-area management plan. Small, contiguous, and relatively exclusive core areas where fishermen are restricted to using limited amounts of habitat-friendly fishing gear as a condition of access and are vetted by fishermen's advisory councils would tend to confer protection on all of the species in them. The limits on and relative exclusiveness of the fishery would serve to reward restraint and stewardship, as it has with lobsters.

Fish, however, are much more mobile than lobsters. Does it make sense to subdivide areas that they are just passing through? That would depend. While large numbers of Atlantic cod and other species migrate seasonally, many others remain behind and provided robust local fisheries into the late 1930s (Goode 1888; Rich 1929). Numerous articles and photos document that large numbers of cod, haddock, cusk, wolffish, winter flounder, Acadian redfish *Sebastes fasciatus*, and others were present along the coast. During the 1920s, for example, areas such as outer Penobscot Bay had cod and haddock fisheries all year. White hake were also available in deeper basins and gullies nearby. Their winter prey species apparently included young-of-the-year Atlantic herring, river herring, shrimp, such as northern shrimp *Pandalus borealis*, Aesop shrimp *P. montagui*, and *P. propinquus*, and other species. The few species still remaining inshore are referred to as "groundtenders" by fishermen.

Groundtenders (Atlantic cod, haddock, and so forth) once utilized inshore spawning sites along the coast of the GOM (Figure 6). Today, most of the sites in the northeastern GOM have been abandoned and appear to be remnants of historically productive areas that have been degraded by repeated depletion and habitat damage. Allowing the metapopulation components associated with those sites to reestablish local reproduction will be important to establishing a sustainable fishery (Seijo 2007). An increase in the number of active spawning areas and nursery sites would increase the long-term probability of producing successful year-classes.

The Multispecies Coastal Shelf Recovery Plan

Several of the issues confronting the GOM multispecies fishery parallel those that were resolved by Maine's lobster zone plan and could be addressed in similar ways if management subunits encompassing subpopulations of Atlantic cod were created. Such subunits would allow the ecological problems affecting the productivity and sustainability of multispecies stocks to be addressed more effectively and at the same time allow intractable socioeconomic problems to be resolved. Consolidation within the industrial fishery could proceed offshore without simultaneously eliminating access to inshore fisheries by coastal fishermen and the general public (Wilson 1997). As in the lobster fishery, smaller units within a larger management system would lead fishermen to realize that they would benefit directly from local restoration efforts and sustainable use.

The challenge is perhaps how to best introduce these innovations into the suite of complex ecologies used by fishermen and fish in the multispecies fishery. The stakeholders in the groundfish industry are more

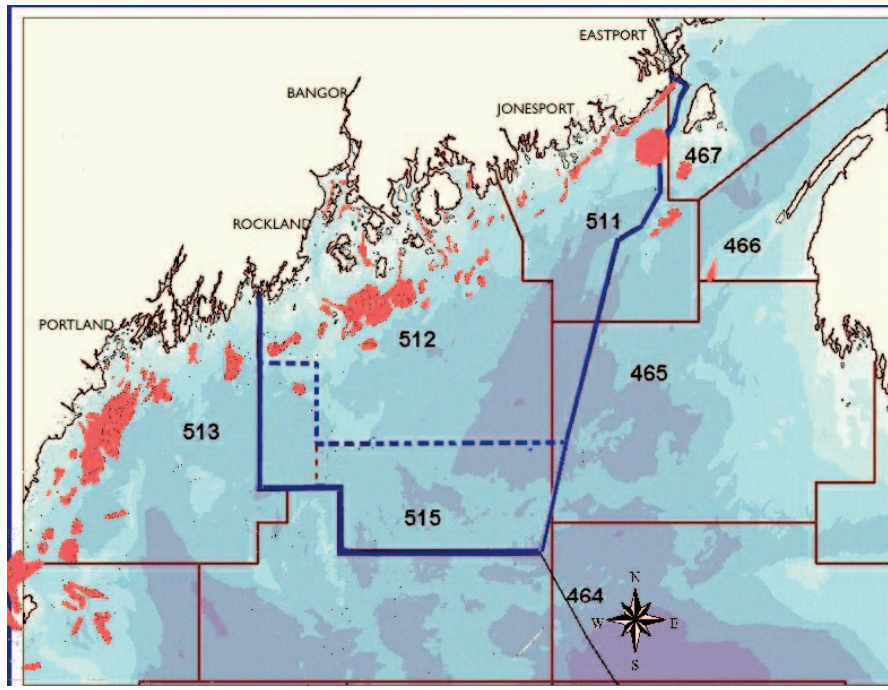

FIGURE 6.—Historical spawning areas of Atlantic cod in the Gulf of Maine (rose-colored areas). The solid blue lines encompass the movements of an Atlantic cod subpopulation. The dashed blue lines are *NAFO* boundaries for Areas 511 and 512.

diverse than those in most other fisheries, and managers have struggled to provide them all with opportunities to fish. Fishing vessels are designed with operational limitations that determine their profitability and make them unsuitable for operations at different scales. While smaller boats tend to be very dependent on local stocks, midsized fishing vessels operate profitably near and along the entire coastal shelf and larger vessels must operate throughout the GOM to remain profitable. Vessels designed to fish offshore are too large to fish sustainably in inshore critical habitats. In the heat of competition, multispecies stocks have been routinely exposed to unsustainable levels of fishing by all vessel classes, resulting in local depletions and the degradation of critical habitats. This often appears as a brief period of high landings that significantly reduces local reproductive capacity, the restoration of which takes years. This pattern of local depletions, combined with today's management policies, has resulted in the selective elimination of many smaller vessels.

The Downeast Groundfish Initiative (DEGI) has developed a plan, the Multispecies Coastal Shelf Recovery Plan, to resolve such issues in a way that is ecologically sustainable and economically efficient for all vessel classes. The MCSRP strategy is to enhance local spawning events, create conditions that will lead to the repopulation of coastal nursery areas, allow juveniles to survive until recruited into the multispecies fishery, and distribute landings equitably. The primary objectives include restoring critical habitats and repopulating the spawning areas, nurseries, and forage stocks used by multispecies groundfish on the coastal shelf. At the same time, the MCSRP creates equity for small and midsized vessels and coastal communities that have lost access to their local multispecies fishery.

The Pilot Project

The DEGI has proposed a pilot project for the northeastern GOM to allow further development and refinement of the MCSRP. The size and location of the project is pivotal, given that it would bracket a historical subpopulation of Atlantic cod and include all multispecies occurring there, along with their spawning grounds, nursery areas, and habitats. The proposed pilot area would manage the ecological needs of all multispecies in management units 511 and 512 (Figure 6) that need minimal modification to bracket a subpopulation of cod. With minor modifications, other units would make appropriate subunits for managing

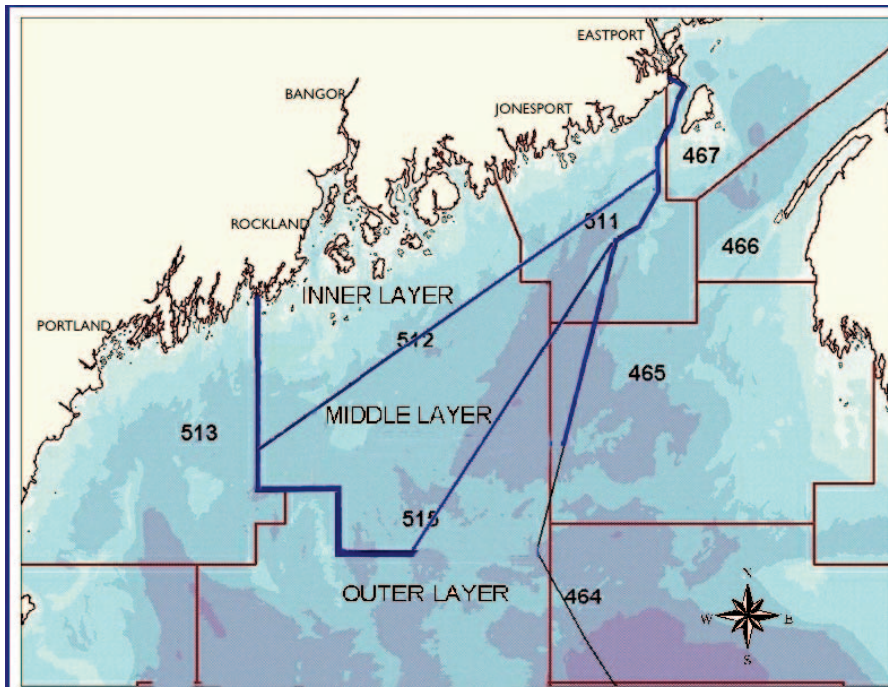

FIGURE 7.—The preferred pilot area for the Multispecies Coastal Shelf Recovery Plan with its three management layers.

the somewhat indistinct ecological boundaries of the cod subpopulations along the New England coastal shelf.

Selection of the Pilot Area

Several factors led to the selection of areas 511 and 512 for the pilot site. The area borders the easternmost 200 km of the U.S. coastal shelf and encompasses an area of approximately 8,000 km^2. Ideally, the southern boundary of areas 511 and 512 would be extended to the Hague Line elbow to encompass the overwintering sites of Atlantic cod and white hake. The long coastline represents approximately one-third of New England's coastal shelf and is characterized by deep, muddy inshore channels and basins edged and separated by sharp, rocky outcroppings that are interspersed with patchy deposits of gravel and sand. The area's groundfish stocks are depleted, though it once held many small, relatively discrete spawning grounds and nursery areas used by several valuable commercial species (Ames 1997; Berrien and Sibunka 1999; Figure 5). The Maine Coastal Current, a coldwater filament of the Labrador Current, flows through the pilot area along the outer edge of the coastal shelf from the Bay of Fundy to the Penobscot Bay–Monhegan Island area to form a large gyre of cooler water in the eastern GOM (Pettigrew et al. 2005), creating an ecologically distinct area.

There are no longer active multispecies fishermen based along the 200-km coastline, and the area is only rarely visited by multispecies fishermen from other parts of New England. The multispecies stocks in areas 511 and 512 have been depleted for more than 14 years. Even though groundfish production from the area was once considerable (Rich 1929), it contributes very little to today's GOM groundfish landings. These factors suggest areas 511 and 512 offer the possibility of recovery and that using them as the pilot area would have little or no effect on today's fishery.

Management Layers

Equally important as using historical Atlantic cod subpopulations to define the management subunits is the need to develop a working strategy that protects critical life stages of groundfish while creating fishing opportunities for each of the three vessel classes. Multiple layers were proposed that would provide each of the three classes with a profitable, sustainable fishery while separating them (Figure 6). To safeguard inshore habitats and concentrations of fish, boats and vessels could not fish closer inshore but could catch at least one-half of their landings from their chosen layer, the rest coming from offshore or an adjoining layer.

The core area.—The spawning grounds and nurseries in the innermost layer (or core) hold the greatest potential for substantially increasing the management subunit's productivity. Several multispecies and prey species have spawning areas and nursery grounds located inside the 25-km-wide inner core layer (Berrien and Sibunka 1999; Ames 2004). A more holistic, pragmatic management approach will be needed in the core area to safeguard the multiple spawning aggregations, juveniles, and their biological communities. The MCSRP proposes to do this by limiting the fishery's scale and mobility in the core area as well as the fishing technology it uses.

Properly designed, a small, supplemental multispecies fishery would diversify existing local fisheries and provide additional recreational opportunities while stimulating various local businesses and giving consumers a greater variety of locally caught seafood. Regulations similar to those used in Maine's lobster zones can create incentives for stewardship and simultaneously address the inequities in fishery access experienced by smaller coastal fishermen and communities.

Core area permits with a minimal amount of catch share or quota attached would be made available to a limited number of local, small-scale owner–operator applicants to supplement their other fishing activities. The conditions of access would include the use of hooks or traps only, weekly landing limits, seasonal restrictions, and contractual loss of access for violations. A low total allowable catch (TAC) for the core area would be appropriate.

The intermediate layer.—A second layer 50 km wide would function as a buffer that provides a fishery for small and midsized multispecies groundfish vessels without endangering local productivity. The seasonal transit of groundfish to and from coastal spawning and feeding grounds will not require the rigorous restrictions of the core area. The intermediate layer would provide a controlled fishery in which all federally approved multispecies gear types are allowed but with limits on the size and number of nets, the length of ground gear, and so forth. To reduce mobility, vessels would be required to catch at least half their annual landings from within their home port area, the balance coming from the outer or a neighboring subunit. A TAC, if imposed, should be significantly higher than that in the core area.

The outer layer.—The third layer would be approximately 200 km wide and include all of the U.S. Exclusive Economic Zone outside of the two coastal layers. The operation of a fishery beyond the coastal shelf would not endanger the base productivity of inshore stocks and would preserve access to traditional offshore fishing grounds. It would be designed to accommodate large, offshore multispecies fishing vessels and would operate under current federal regulations.

Adapting the MCSRP to Quota-Based Systems

The MCSRP is designed to address the life stage bottlenecks of the multispecies assemblage by imposing gear and mobility constraints on fishermen accessing the two inner coastal shelf layers. Management subunits based on subpopulations of Atlantic cod would be formed by modifying the existing North Atlantic Fisheries Organization management units. The plan could, however, function equally well with catch shares simply by regulating the maximum amount of catch share allowed an individual vessel applying for access to inner layers. For example, vessels allowed minimal amounts of catch shares and using limited numbers of hooks in the core area would be permitted to fish anywhere, even though they would rapidly fill their annual quota. Vessels with intermediate amounts of catch shares could fish in either the middle or outer layer, provided that at least half their landings came from their chosen middle layer (a moderate quota). Those exceeding the middle layer quota limit could fish anywhere outside the middle area, including Georges Bank (a large quota).

Conclusion

The Multispecies Coastal Shelf Recovery Plan offers an ecosystem-based approach to restoring the multispecies fishery in the GOM and rendering it sustainable. The key to the plan's success is to change fishing practices in the two outer areas as little as possible while limiting access to and mobility in the critical-habitat areas. This approach limits fishing effort in areas essential to the biological productivity of several multispecies stocks in order to improve the total yield in the fishery. In return, it enhances the profits of all three vessel classes while providing expanded recreational fishing opportunities.

This approach offers to simultaneously resolve equity issues among user groups and revitalize coastal communities by restoring coastal fishing, local marketing activities, and recreational uses while introducing stewardship incentives to the fishery. The MCSRP would make Atlantic cod subpopulation regions into multilayered management subunits with community-based input that integrate seamlessly into regional council and state management systems in much the same way as the lobster management plan. Data needs and expenditures should be minimal.

The fisheries in the three layers are designed to function at different scales under limits that safeguard

their biological productivity. This would enable the contiguous core areas to function as production-enhancing units—brood chambers to create a large, sustainable, and equitable multispecies fishery for all three vessel classes—while restoring the vibrant and diverse small-scale multispecies fisheries that were traditionally an economic component of New England's smaller coastal communities. It would not be unreasonable to expect the improvements in the multispecies fishery to be as substantial as those in the lobster fishery.

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