

A Review of Gulf of Mexico Marine Protected Areas: Successes, Failures, and Lessons Learned

ABSTRACT

Commercial and recreational fishers in the Gulf of Mexico routinely express in public testimony their concern over the number of fishery regulations in general, and the prospect of having closed areas that affect their opportunities to fish. Of the 16 closed areas, or marine protected areas, in the Gulf that restrict shrimp and reef-fish fishing, most have not provided anticipated protection for exploited species. The unintended consequences in several cases affect other fisheries or endangered species by shifting fishing effort and thus increasing the vulnerability of additional populations. Three areas are so new that few data are available to demonstrate their effectiveness, although preliminary data are promising. The main problems hindering the effectiveness of Gulf closed areas are ill-conceived development, lack of performance monitoring, and inadequate enforcement. We suggest that well-designed Gulf closed areas be created to address fishing gear impacts on habitat, provide an area free of fishing to allow scientists to obtain accurate estimates of natural or fishing mortality critical to fishery stock assessments, and protect source populations.

Introduction

Marine protected areas (MPAs) of one type or another have been around for millennia, especially in artisanal fisheries worldwide (Johannes 1978; Agardy 2000). They are being recommended now in the United States by fisheries managers, scientists, conservationists, and some fishers who see them as a means of improving fishery production and reversing the trends that ultimately have led to overexploitation of nearly one third of assessed U.S. fish stocks (NMFS 2002; Bohnsack 2003). The question is, how successful have they been?

The perception among advocates is that few other management strategies are as conceptually simple, are as easily enforced, or provide as great a potential return as MPAs. The litany of problems closed areas might address includes conservation of biodiversity and habitat, improvement of scientific knowledge, education, enhancement of recreational opportunities, provision of environmental benefits, protection of cultural heritage, intrinsic existence value, and improved fishery management through larval export, adult spillover, and protection of life stages that form bottlenecks to production (NRC 2001).

Worldwide, MPAs have had highly variable success rates, and much of today's debate involves their potential to accomplish very specific fishery-management objectives. Case studies and theoretical modeling suggest that scientifically sound no-take MPAs—marine reserves—can benefit fisheries (Crowder et al. 2000; Mangel 2000; Lindholm et al. 2001), but the evidence is still rather limited that within-boundary benefits such as increased fish abundance or reproductive output are exported to fished areas (see reviews in *Bulletin of Marine*

Science, March 2000 Special Issue; NRC 2001; Ecological Applications, March 2003 Special Feature; *Frontiers in Ecology and the Environment*, November 2003 Forum).

The Gulf of Mexico Fishery Management Council (Gulf Council) has used marine protected areas as a management strategy for the last 25 years, establishing 16 MPAs to address various regional societal and ecological problems. Our intent here is to

- (1) describe each of the MPAs listed in the Code of Federal Regulations 50CFR622.34 as Exclusive Economic Zone (EEZ) seasonal or spatial closures for shrimp, reef fish, and habitat (Table 1, Figure 1);
- (2) identify for each MPA the relationship between the fishery problem, the management objective, and the regulation implemented; and
- (3) evaluate the degree to which it meets stated management objectives.

We intentionally ignore sanctuaries established by local and state laws, National Marine Sanctuaries (for the most part), and National Estuarine Research Reserves, because these are not managed by the Gulf Council and thus are beyond the scope of the present article. Finally, we provide a list of lessons learned that is intended to help in the decision-making process about use of MPAs.

Marine Protected Areas in the Gulf of Mexico

For purposes of this discussion, we identify four categories of MPAs on the basis of the primary management objectives defined by the Gulf Council and National Marine Fisheries Service (NMFS) (recognizing that some MPAs address multiple objectives). These categories include MPAs created to:

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Table 1. Marine protected areas for fishery management in state and federal waters of the Gulf of Mexico. Sources: 50CFR622.34 and Gulf of Mexico Fishery Management Council Fishery Management Plans for fisheries including stone crab (GMFMC 1979, and amendments), shrimp (GMFMC 1981a, and amendments), and reef fish (GMFMC 1981a, and amendments). EEZ = exclusive economic zone. NM = nautical mile.

| NAME AND YEAR ESTABLISHED | SIZE (NM²) | DURATION | PROBLEM IDENTIFIED | OBJECTIVE(S) | PROHIBITIONS |
|-------------------------------------------------------------------|------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| MPAs intended to solve allocation issues | | | | | |
| Southwest Florida Seasonal Trawl Closure, 1979 | 1,489 2,562 | Jan 1–May 20 (state waters) Oct 1–May 31 (federal waters) | Gear conflicts between shrimp and stone-crab fishermen | Eliminate gear conflicts | Shrimp trawling |
| Shrimp/Stone Crab Separation Zones, 1984 | 174 | Various | Gear conflicts between shrimp and stone-crab fishermen | Eliminate gear conflicts | Shrimp trawling, stone-crab trapping in five zones |
| Alabama Special Management Zone, 1994 | 712 | Year-round | Intense fishing by commercial bandit-rig fishermen on artificial reefs constructed by hook-and-line commercial and recreational fishermen | Limit commercial fishing on artificial reefs | Reef-fish gear with >3 hooks per line |
| MPAs intended to increase fishery yields | | | | | |
| Texas Closure, 1981 | 28,782 | May 15–Jul 15 | | Increase yield and value of brown shrimp catches | Shrimp trawling |
| Tortugas Shrimp Sanctuary, 1981 | 3,652 | Year-round | | Increase yield and value of pink shrimp catches | Shrimp trawling |
| MPAs intended to reduce fishing effort | | | | | |
| Reef Fish Stressed Area, 1984 | 48,400 | Year-round | Intense recreational fishing on nearshore reef-fish populations | Relieve stress on nearshore reef-fish population | Powerheads for reef-fish harvest, fish traps, roller trawls |
| Reef Fish Long-line/Buoy Gear Restricted Area, 1990 | 72,300 | Year-round | Intense commercial fishing on spawning reef-fish populations | Reduce fishing pressure on spawning reef-fish populations by pushing fishery farther offshore | Longline/buoy gear for harvest of reef fish |
| Madison Swanson and Steamboat Lumps, 2000 | 115 104 | Year-round | Decline in proportion of males in population | Study marine reserves used to protect male gag grouper | All fishing except for “highly migratory species” |
| Red Snapper Commercial Seasonal Closure, 1992 | EEZ, all state waters | Various | Red snapper stocks overfished | Reduce commercial catches of red snapper. | Possession and sale of red snapper |
| Red Snapper Recreational Seasonal Closure, 1997 | EEZ, all state waters | Jan 1–Apr 20, Nov 1–Dec 31 | Red snapper stocks overfished | Reduce recreational catches of red snapper | Recreational bag limit of zero |
| Riley’s Hump Seasonal Closure, 1994 | | May-June | Declining recreational catches of mutton snapper | Protect mutton snapper stocks by closing spawning sites to fishing during peak spawning season | All fishing |
| Gag/Red/Black Grouper Commercial Seasonal Closure, 2000 | EEZ, all state waters | Feb 15–Mar 15 | Gag stocks approaching overfished condition | Protect grouper by banning commercial catches for one month during peak spawning | Possession, sale, and purchase of gag, red, and black grouper |
| MPAs intended to protect ecological structure and function | | | | | |
| East and West Flower Garden Banks HAPC | 41 | Year-round | Need to protect coral resources | Protect coral from gear damage, collection | Coral harvest; bottom longlines, traps, pots, bottom trawls, anchoring of vessels |
| Florida Middle Grounds HAPC | 348 | Year-round | Need to protect coral resources | Protect coral from gear damage, collection | Coral harvest; bottom longlines, traps, pots, bottom trawls |
| Tortugas Ecological Reserve, 2001 | 151 | Year-round | Special pristine habitat unprotected | Protect reef fish populations and habitat, preserve ecosystem function and structure | All fishing |

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The shrimp boat *Miss Marissa* at dock in Palacios, Texas.

- (1) solve allocation issues,
- (2) increase fishery yields;
- (3) reduce fishing effort and protect population demographic features, or
- (4) protect ecological structure and function.

MPAs Intended to Solve Allocation Issues

Conflicts inevitably arise in regions with diverse fisheries and varied cultures when competing interests vie for different stocks within the same space, or for the same stocks within a limited space. We provide examples of each of these conditions.

Stone crab/shrimp closures. The state of Florida long considered the area within 12 nautical miles (NM) of shore a shrimp nursery (Florida Statute A 370.151), effectively eliminating shrimp trawling and permitting stone crabbing. When the U.S. Supreme Court limited state water jurisdictional boundaries to 9 NM for the Gulf coasts of Florida and Texas, and 3 NM for other coastal states, fishing patterns shifted. The smaller trawling exclusion zone off Florida's Gulf coast (from 12 to 9 NM) resulted in increased interactions between shrimp and stone-crab fishers (GMFMC 1979) exacerbated by: declining East Coast shrimp catches, which caused the shrimp fishery to contract to the Gulf; increased competition among U.S. shrimpers forced out of Mexican and Cuban waters when those countries established their own EEZs; and expansion of the stone-crab fishery (GMFMC 1979, 1981c, 1984).

Forcing these two quite different gears—mobile shrimp trawls and stationary pots—into the same limited space resulted in conflicts that escalated from accidental to deliberate property damage and threats of bodily harm (GMFMC 1984). State and federal managers tried to ward off “a major armed conflict” by separating them in distinct fishing zones: one temporal, shifting from one fishery to the other every 6 months—the Southwest Florida Seasonal Trawl Closure (GMFMC 1979)—and the other both temporal and spatial—the five Shrimp/Stone Crab Separation Zones (GMFMC 1984) (Table 1, Figure

1a, b). Although no formal evaluation of either closure has occurred, the Gulf Council considers the conflict resolved (GMFMC 2000a) while the state of Florida maintains a significant law-enforcement presence to forestall armed confrontations (Major Bruce Buckson, Florida Marine Patrol, pers. comm.).

Alabama Special Management Zone.

Recreational and commercial hook and line (gear with 1–3 hooks per line) and bandit gear (gear with up to 30 hooks per line) fishers have for years built artificial reefs off the Alabama coast to enhance their fishing opportunities. The “reefs” are primarily discarded automobiles, sunken ships, toppled oil platforms, and bridge rubble placed at depths ranging from 2 to 70 m (GMFMC 1993).

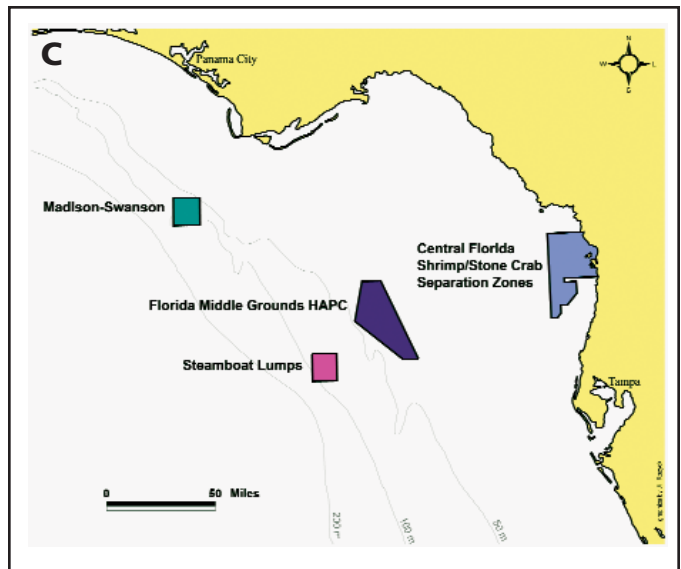
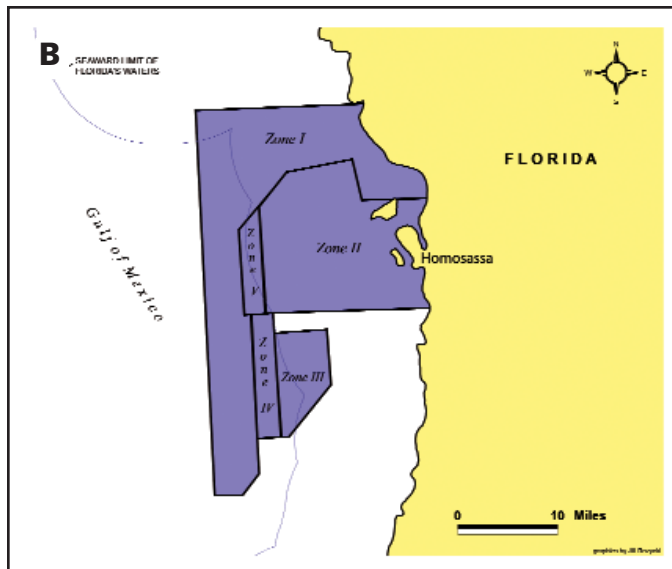
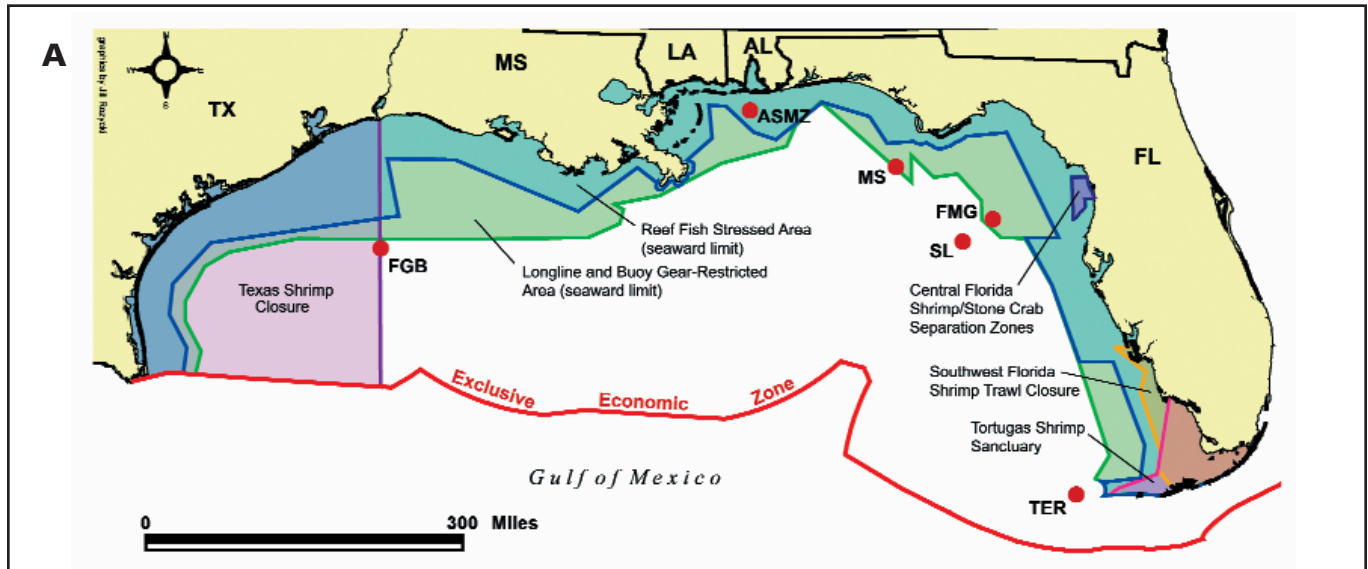
When the Gulf Council implemented per-trip catch limits and short derby fishing seasons in the commercial red snapper (*Lutjanus campechanus*) fishery in 1992, commercial bandit-rig fishers tried to maximize their number of daily trips by fishing closer to shore, sometimes on the artificial reefs. Other fishers using the reefs complained that their fish were in essence being stolen. The Council responded by establishing the Alabama Special Management Zone (ASMZ) (Figure 1a), limiting access to hook and line fishers and restricting those with bandit gear onboard to the recreational bag limit (GMFMC 1993), all but eliminating the commercial sector from the reefs.

The effectiveness of the ASMZ has not been formally evaluated. Alabama fishery managers report high compliance and high incentive among local fishers to report violators (Vernon Minton, Natural Resources Division, Alabama Department of Conservation and Natural Resources, pers. comm.).

MPAs Intended to Increase Fishery Yields

The Texas shrimp fishery, pursuing white shrimp (*Litopenaeus setiferus*) and brown shrimp (*Farfantepenaeus aztecus*), and the Florida shrimp fishery, pursuing primarily pink shrimp (*Farfantepenaeus duorarum*), are managed cooperatively by state and federal resource agencies. Gulf managers largely view the fisheries as immune to recruitment overfishing because the species complete their life cycles in one year—even though recruitment overfishing of shrimp is a recognized problem in Mexico (Gracia 1991, 1996; Gracia and Vazquez-Bader 1999), Kuwait (Mathews 1994), and China (Penn and Caputi 1984). Thus, they manage stocks to increase fishery yields (GMFMC 1981a) rather than maintain high spawning stock size.

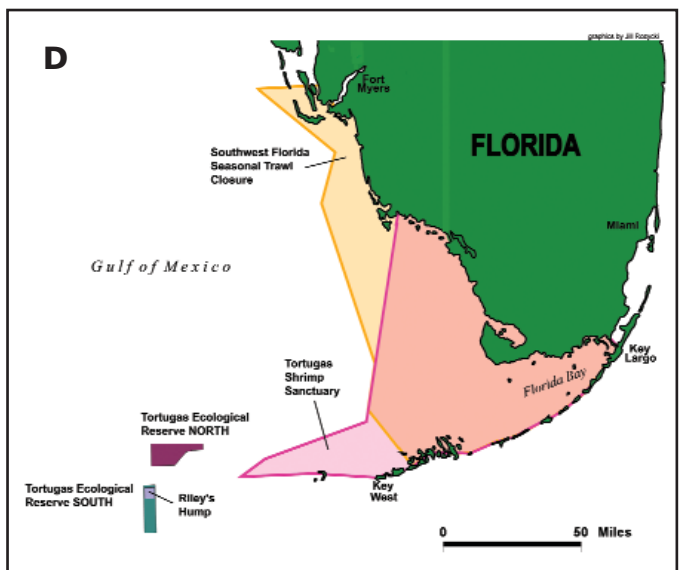
Figure 1. Marine protected areas in the Gulf of Mexico. (a) entire Gulf region; (b) Central Florida Shrimp/Stone Crab Separation Zones; (c) northeastern region (d) southwest Florida. FGB = Flower Garden Banks, FL = Florida, FMG = Florida Middle Grounds, HAPC = Habitat Area of Particular Concern; MS = Madison-Swanson, SL = Steamboat Lumps, TER = Tortugas Ecological Reserve.



This is accomplished to some extent through the use of areas closed to trawling during summer off Texas and year-round off Florida.

The Texas closure. Resource managers in Texas during the 1960s and 1970s identified the excessive catch and discard of undersized brown shrimp (>65 tails per pound) in nearshore waters as the primary reason for problems in the fishery (Klima 1989). They felt that a nearshore closure would eliminate this problem, as well as the need for a minimum-count law, while producing larger shrimp with greater dockside values (GMFMC 1981a; Klima 1989), and the closure was put in place in the early 1980s.

NMFS monitored the shrimp fishery from 1981 to 1986, and attributed Gulf-wide increases in brown shrimp yield of up to 10% and ex-vessel values of \$60 million to the closure. NMFS also reported higher CPUE and declining shrimp discards in the Texas fishery (Klima 1989). Satisfied that these results would continue, the Gulf Council voted in 1986 to restrict monitoring to yield, subsequently identifying yield increases (for example, 6 to 27% in 2000)



higher than would be realized without the MPA (Nance 2000).

The Texas Closure automatically provides seasonal protection for endangered sea turtles that mate and nest in Texas during summer months—particularly Kemp’s ridleys. This benefit is counteracted by an unintended consequence—a high number of sea-turtle strandings before closing and immediately after reopening of the area to shrimping (Shaver 1998, 2002). This problem, among others, led the Texas Parks and Wildlife Department to establish a seasonal (December to mid-July) closure when turtles are most vulnerable to capture, extending from the state’s barrier island beaches from Corpus Christi to Brownsville, Texas, out 5 NM.

The Florida closure. As early as 1956, Florida’s shrimp fishery experienced declining landings of large shrimp, increasing discards of small shrimp, depletion of the overall stock, and growing overcapacity in the fishery (Klima et al. 1986). These problems led to establishment of the Tortugas Shrimp Sanctuary in 1981, largely through the efforts of commercial shrimpers and the Southeastern Fisheries Association intent on protecting a portion of Florida’s primary pink shrimp nursery grounds (Robert Jones, Southeastern Fisheries Assn., pers. comm.).

Managers expected a 1 million lb. (453,600 kg) annual increase in yield after establishment of the sanctuary (GMFMC 1981a). Further, they anticipated that catch statistics before (1960–1979) and after (1981–1983) MPA establishment would demonstrate a spillover effect from the sanctuary. However, the high number of violations (27) and low compliance (65%) during the years immediately following implementation apparently prevented any potential increases in yield and a valid evaluation of the MPA’s effectiveness (Klima et al. 1986).

The situation has not improved. Indeed, current evidence indicates declining stocks, which managers attribute to environmental rather than fishing effects (Nance 2001). In fact, the entire south Florida ecosystem, particularly within Florida Bay, has experienced significant sea-grass die-offs, high water temperatures, and hypersalinity resulting from diversion of freshwater flows (Browder et al. 1986; Gilmore and Snedaker 1993; Ogden 1994; Fourqurean and Robblee 1999). Further, stock declines encourage boundary violations by fishers who anticipate higher CPUE within the sanctuary and are willing to take the risk of being detected. As a result of 16 violations reported in 2000, enforcement agents seized more than 50,000 lb. (22,680 kg) of illegal shrimp (Proulx 2001).

MPAs Intended to Reduce Fishing Effort

Many Gulf fisheries are plagued by excess fishing effort. Increases in the numbers of boats and fishers, coupled with technological advancements in fish-finding and capture equipment, allow even novice fishers improved fishing success. Recognizing this problem, the Gulf Council has established eight MPAs—as

either seasonal or spatial closures—each of which is expected to reduce effort, reduce overfishing, and contribute to rebuilding of overfished stocks.

Reef Fish Stressed Area and the Longline/Buoy Gear Restricted Area (Spatial). In the late 1970s, the Gulf Council recognized intensive recreational fishing on young fish in nearshore waters and commercial longline fishing on spawning adults in offshore waters as significant contributors to declining reef fish (mostly red snapper) populations in the Gulf of Mexico (GMFMC 1989). The bottom longline fishery, in which individual boats typically make two sets of 30-mile line with 2,500 hooks per set, was targeted because their gear appeared to be more efficient than the traditional hook-and-line and bandit gear long employed in the Gulf (GMFMC 1989).

The Council called the area most influenced by recreational fishing throughout the Gulf the “Reef Fish Stressed Area.” The seaward boundary of this area is farthest from shore near densely populated areas where recreational fishing pressure is most intense, and closest to shore in areas of lower population density where fishing pressure is less intense (GMFMC 1981b, 1989) (Figure 1a). In a perplexing move, the Council then implemented gear restrictions in this area aimed almost entirely at the commercial sector, excluding the use of powerhead (explosive tipped) spear guns (used by a very few recreational and commercial scuba divers), fish traps, and roller-rig trawls (which were not used at all within the designated area). In effect, the identified problem of intensive recreational fishing in this zone remains unaddressed, and the effectiveness of the stressed-area closure has not been evaluated. Regardless, the Council expanded the stressed zone in 1989 to include additional areas off Texas and Louisiana on the basis that the expansion would reduce fishing mortality near shore, even while stating that “...the relative impacts of this measure on reef fish stocks and reduction in fishing effort effected are not known” (GMFMC 1989: 271).

The Gulf Council also identified the Longline Buoy Gear Exclusion Zone throughout the Gulf as some 72,000 NM² inshore of the 50-fa (91.5-m) isobath, except off Florida, where, the boundary was the 20-fa (36.6-m) isobath east of longitude 85°30’ (off Cape San Blas) to avoid disruption of Florida’s expanding longline grouper fishery (GMFMC 1989, Figure 1a). Even before implementing the regulation, the Council correctly predicted that this MPA would have little chance of reducing effort because the void created by moving longline fishers further offshore would quickly fill with both recreational and other commercial fishers. Although no formal evaluation of this MPA has occurred, the objective of reducing catches was clearly not achieved, and limiting pressure on spawning reef fish was almost certainly not accomplished over the long term, given the state of grouper fisheries in the region (Coleman et al. 1996). To some extent, the movement offshore of longliners may actually have increased pressure on spawning populations

of reef fishes, many of which aggregate on the continental shelf (Koenig et al. 2000).

At the time of this writing, the Longline/Buoy Gear Restricted Area is being considered for expansion off Florida, moving the seaward boundary from the 20-fathom to the 50-fathom isobath east of 85°30' west longitude. The proposed change is intended to reduce catches of overfished red grouper stocks by as much as 38 to 43%, and result in conversion of 60 to 80% of the longline fishery to bandit rigs (GMFMC 2002). History suggests these changes will fail to achieve the objectives because commercial and recreational sectors will respond to the movement of longliners further offshore by expanding effort to fill the longline void in areas shallower than 50 fathoms. Further, expansion of the Longline/Buoy Gear Restricted Area could have unintended negative consequences on other exploited stocks. Most notably—as recognized by the Gulf Council when the zone was first established—pushing the longline fishery farther offshore could increase fishing pressure on the deep-water reef-fish complex, including tilefish (*Lopholatilus chamaeleonticeps*) and yellowedge grouper (*Epinephelus flavolimbatus*, GMFMC 1989, 2002). The recent quota reduction for the overfished mid-Atlantic tilefish could also contribute to increased pressure on Gulf tilefish stocks to fill the void of reduced catches in the mid-Atlantic. It is unlikely that either Gulf tilefish or deep-water grouper species could endure sustained intense fishing pressure without collapsing (Coleman and Williams 2002). The Council's response to this possibility is to propose caps for tilefish and deep water grouper catches based on the current (1996–2000) landings (GMFMC 2002). Whether these quotas represent sustainable levels of fishing is unknown at this time.

Closures in the Commercial and Recreational Red Snapper Fishery (Seasonal). The red snapper stock of the Gulf of Mexico has been overfished since the early 1980s (GMFMC 1981b). Attempts to limit catches focus on the use of a total allowable catch (TAC) in concert with seasonal closures and trip and bag limits intended to keep fishers within the TAC.

The 1990 TAC set for this stock was 6.07 million lbs. (2.75 million kg), giving the commercial sector a quota equivalent to 51% and the recreational sector 49% of the TAC. Under this system, commercial seasons typically lasted a matter of months. In 1994, for example, the season lasted only 54 days, leading the Council to attempt effort reduction and season extension by implementing a limited-entry program, commercial per-trip catch limits, higher minimum size limits, a spring-fall split season in 1996 (GMFMC 1996), a 15-day mini-season (fishing allowed the first 15 days of the month) in 1997 (GMFMC 1997), and most recently a 10-day mini-season (GMFMC 1998b, 2000b). During this period, the recreational sector routinely exceeded its TAC allocation and still remained open. When excesses reached 90%, Congress intervened, calling for a recreational quota system that required a closure after the quota filled (GMFMC 1997). After 3 years of operation under these guidelines, the recreational fishing season has declined in length from 12 to 6.5 months.

Quota management with closed seasons has failed to stem overfishing and has resulted in derby fishing in the commercial sector and



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A local longline boat with a 2,200 lb. catch of yellowedge grouper off Apalachicola, Florida.

missed fishing opportunities in the recreational sector. Further, it has kept the Gulf Council in a decades-long crisis-management mode.

Riley's Hump Closure (Seasonal). Riley's Hump, a small (11 NM²), discrete reef bank rising 30 m off the seafloor in an area southwest of the Tortugas (Figure 1d, part of the Tortugas Ecological Reserve South since July 2001, described below), is an important spawning site for many reef fishes, including gray snapper (*L. griseus*), cubera snapper (*L. cyanopterus*), dog snapper (*L. jocu*), and yellowtail snapper (*Ocyurus chrysurus*) (Lindeman et al. 1998), as well as black grouper (*Mycteroperca bonaci*) and ocean triggerfish (*Canthidermis sufflamen*) (NOAA 2000). It is the only known spawning site for mutton snapper (*Lutjanus analis*). To improve recreational catches of mutton snapper, the Gulf Council closed Riley's Hump to all fishing during mutton snapper spawning season (May and June) after noting 80% declines in the mutton snapper recreational landings over a 10-y (1981–1991) period (GMFMC 1993).

Neither the effect of the closure on mutton snapper nor its effect on other stocks in the community were ever evaluated. Of great concern is the effect the limited closure could have on other spawning stocks. For instance, dog, cubera, and gray snapper spawn later in the season than mutton snapper, and thus could be exposed to more intense fishing pressure when Riley's reopened each year (Lindeman

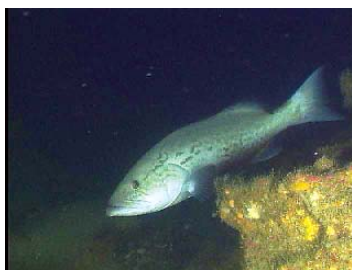
et al. 1998). In addition, commercial landings of mut-ton snapper considered stable at the time the closure went into effect have declined by 30–50% since (NMFS, Fishery Statistics and Economics Division, Silver Spring, MD, pers. comm.).

Madison-Swanson and Steamboat Lumps Fishery Reserves (Spatial). In the mid 1990s, we (Coleman and Koenig) noted a disturbing decline in the proportion of males in the populations of both gag (*Mycteroperca microlepis*) and scamp (*M. phenax*), which are protogynous hermaphrodites with complex social conditions for sex change (Coleman et al. 1996). By 1998, NMFS reported significant declines in gag stocks, suggesting that the species was approaching an overfished condition (Schirripa and Legault 1997). The problem seemed to stem at least in part from intense fishing on spawning aggregations on the continental shelf edge, as has occurred in other grouper stocks worldwide (Sadovy and Eklund 1999, Coleman et al. 2000). Aggregation sites for reef fishes tend to be consistent in time and space, making them easy and routine targets for fishers.

Because it appeared that male gag remained on aggregation sites long after the spawning season while females migrated between spawning and feeding sites (Koenig and Coleman, unpublished data), the Gulf Council suggested closing aggregation sites to fishing to determine whether an MPA could protect males and perhaps re-establish the historic demographic make-up of the population (GMFMC 1999). The compromise over which areas to close, and for how long, resulted in the choice of two sites covering a total of 219 NM² of relatively marginal aggregation sites already heavily fished, and an experimental closure period of 4 years (2000–2003).

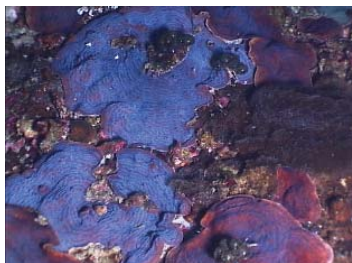
The work we have conducted in the reserves over the past four years relied heavily on the input and participation of commercial fishers. Results are promising, indicating that males are remaining on site long after the spawning season, and that the CPUE of male gag and scamp within reserve boundaries is much higher than that in reference sites outside of the reserves (Koenig and Coleman, unpublished data). Based largely on these compelling preliminary data, which show that population demographics can be recovered in a fairly short period of time (even after intensive fishing), the Gulf Council recently voted to extend the closure an additional 6 years to continue tests of the efficacy of using MPAs to manage grouper stocks (GMFMC 2003).

This case is significant for a number of reasons: it was the first time that behavioral aspects of exploited stocks were considered, particularly the social structure that influences sex change; MPA monitoring has continued unabated since the reserves were



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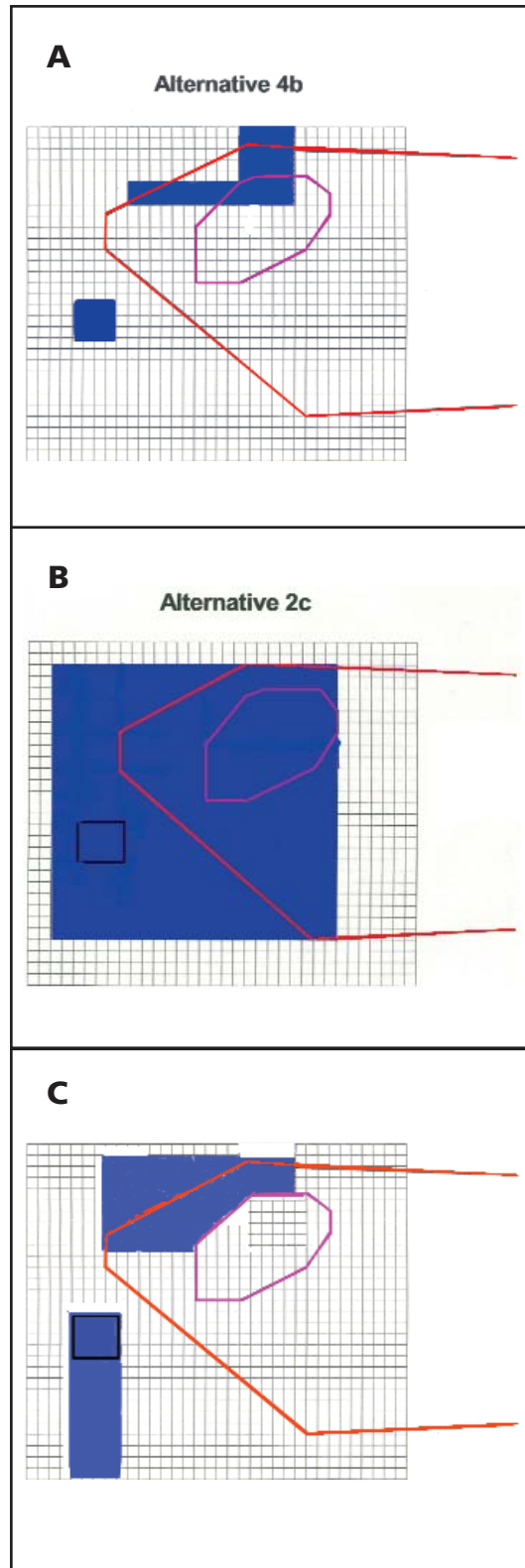
A male gag in Steamboat Lumps Marine Protected Area.



NATIONAL GEOGRAPHIC

A view of platy lettuce corals (*Leptocercis cucullata*) and sea pearl macroalga (*Ventricaria ventricosa*) 65 meters deep on Pulley Ridge.

Figure 2. Alternatives chosen by Tortugas 2000 Working Group for establishment of the Tortugas Ecological Reserve. (A) Smallest alternative chosen (total = 55 NM²); (B) largest alternative chosen (lower portion extends throughout entire economic exclusive zone; total = 600 NM²); (C) Final design for Tortugas Ecological Reserve (total = 151 NM²). Solid orange line = Florida Keys National Marine Sanctuary boundary. Solid purple line = Dry Tortugas National Park boundary. Black box = Riley's Hump.



established; and involvement of commercial fishers has led to significant buy-in, even by those strongly opposed to their formation (Neils 2003).

Grouper Commercial Seasonal Closure (Seasonal). In addition to the spatial closures established in 2000 to protect male gag, the Gulf Council established a seasonal closure (February 15 to March 15) during peak gag spawning in an attempt to reduce annual catch of gag stocks approaching an overfished condition. Because gag co-occur with red grouper and to some extent black grouper (at least in the southern part of gag's range), the seasonal closure extends to these other species to prevent the incidental capture of gag by fishers seeking these other species. During the closure, the possession, sale, and purchase of gag, black, and red grouper is prohibited throughout the Gulf.

The Gulf Council expected the closure to reduce commercial gag and black grouper landings by 10% and red grouper landings by 6%. This expectation was based on the erroneous assumption that fishers would not shift their effort to periods before and after the seasonal closure (GMFMC 1999). Our evaluation of the commercial landings reported to the Florida Fish and Wildlife Conservation Commission revealed that gag catches in 2001 were 59.8% higher than those in 1999 and 43.7% higher than those in 2000. The total shallow-water grouper catches were 10.7% higher in 2001 than they were in either 1998 or 1999. This one-month closure has not contributed to reducing landings in the gag fishery, and clearly has resulted in effort shifting. Further, the closure only applied to commercial fishers, even though recreational fishers take the bulk of the gag catch (Schirripa and Legault 1997; Dayton et al. 2002). A repeal of this measure is currently under consideration.

MPAs Intended to Protect Habitat and Ecological Structure and Function

Habitat Areas of Particular Concern. In addition to managing fish stocks, the Gulf Council is responsible for protecting essential fish habitat and for managing the coral and coral-reef resources of the region. It does so primarily by designating Habitat Areas of Particular Concern (HAPC).

Two lists of Gulf of Mexico HAPCs have emerged over the last 25 years. The first appeared in the joint coral plan for the Gulf of Mexico and the South Atlantic (GMFMC 1982), and the second in the Gulf of Mexico Essential Fish Habitat Amendment (GMFMC 1998a). Of all the areas identified as HAPCs, only two of those from the original list are afforded protection: the East and West Flower Garden Banks and the Florida Middle Grounds (GMFMC 1982).

The East and West Flower Garden Banks, in the northwestern Gulf off Texas (the Flower Garden Banks National Marine Sanctuary since 1992), are part of a series of salt-dome hard banks that occurs on the continental shelf (extending westward to include the Topographic Highs off Texas). The Florida Middle Grounds, in the northeastern Gulf off central Florida, contains a relatively high-relief community of stony coral and octocorals. Together, these areas represent the northernmost extent of coral communities in the United States (Lugo-Fernandez 1998). They are protected from coral harvest and the use of fishing gear that could damage coral communities, including bottom longlines, traps, pots, bottom trawls, dredges, and toxic chemicals. No other fishing restrictions apply. Hook-and-line fishing is intense but largely unquantified in both regions.

The Gulf Council is currently considering other sites for protection, including Pulley Ridge, a feature off the west Florida continental shelf edge west of the Tortugas between 24°20' and 26°40' north lat-

itude at depths of 60–80 m. U. S. Geological Survey oceanographers and scientists from other organizations are studying a unique, previously undescribed (but not unknown to fishers) coral formation at the southern end of Pulley Ridge. The benthic community at these depths is unusual in that it is dominated by the agaricid corals *Leptoseris cucullata* and *Agaricia* sp., and by the green alga, *Anadyomene* spp. It also contains stony corals, including *Montastraea cavernosa* and *Porites* sp. and fairly abundant coralline red algae and sponges. Designation as an HAPC could provide protection for the coral structure from the damaging effects of fishing and boating activity (e.g., trawling, longlining, anchoring), depending on what category of HAPC the Council decides to put in place.

Tortugas Ecological Reserve. After a long (1995 through July 2001) and conflicted interjurisdictional process that involved two federal fishery management councils (the Gulf and the South Atlantic), the National Park Service, the National Marine Sanctuary Program, NMFS, and the state of Florida, the Tortugas Ecological Reserve became the first strictly no-take MPA, or marine reserve, in the Gulf of Mexico (Table 1, Figure 1d).

The affected users perceived the original (1995) plan drafted to establish these reserves as a top-down managerial attempt to effect fisheries policy that ultimately would result in economic harm to their communities. Commercial fishers, treasure hunters, real estate companies, and residents with waterfront property opposed it, finding the concept of no-take ecological reserves unacceptable (Suman et al. 1999). Conservationists opposed it on the basis that the plan provided insufficient habitat protection, and shrimpers opposed it because they felt they lost too much fishing ground.

The second attempt (1998–2001) to establish reserves shifted to a bottom-up approach by developing a 24-member working group composed of commercial and recreational fishers and divers, environmentalists, scientists, and managers from state and federal agencies with a clear objective to design a reserve that provided coral-reef habitat protection without unduly affecting the users (NOAA 2000; Cowie-Haskell and Delaney 2003; Delaney 2003). Social scientists and economists engaged in the process developed regional maps that included a geographic information system (GIS) database encompassing these components: important oceanographic features and their perceived role in retaining fish larvae, lobsters, and other species for the Florida Keys and the east coast of Florida; species-distribution maps of all exploited stocks; and social and economic maps indicating the distribution of user group activity over time and space (e.g., amount of catch, number of days fished, value of catch, Leeworthy and Wiley 2000).

On the basis of these maps, the group produced 12 possibilities for reserve placement and design that ranged from most user friendly (i.e., providing less protection) to most conservation oriented (i.e., providing more protection) (Figure 2). The outcome was that this diverse group devised an ecosystem approach focusing on natural resource protection rather than particular jurisdictional, allocation, or fishery issues, unanimously agreeing to establish the 151-NM² Tortugas Ecological Reserve (incorporating Riley's Hump).

Lessons Learned

Lesson 1:

The Regulatory Action Must Match the Regulatory Objective

We found discrepancies in many of the Gulf MPAs between the identified problem, the objectives of management, and the regulation ultimately implemented. MPAs that lack a priori planning not only are doomed to fail but provide a false sense of having a management

program while providing little or no benefit (Allison et al. 1998). Worse, a poorly planned MPA may exacerbate rather than solve fishery problems (Crowder et al. 2000).

We often found it difficult to find congruence between the problem and the plan proposed to solve it. Although the problems identified in the establishment of each MPA were relatively clearly defined, the solutions offered often failed fundamentally to address them. The Reef Fish Stressed Area provides an example. The problem identified was overfishing of nearshore reef-fish populations caused by intense recreational fishing pressure, but the regulations implemented limited only the use of commercial fishing gear and only gear not actively used in the designated area. Although exclusion of these gears could be construed as proactive to prevent future problems, the identified problem was not addressed, and we found no evidence or theoretical basis that the MPA reduced, or ever had the potential to reduce, existing fishing effort within its boundaries.

**Lesson 2:
Gulf MPAs Can Help Solve Allocation Conflicts**

The Southwest Florida Seasonal Trawl Closure and the central Florida Shrimp/Stone Crab Separation Zones are reasonably successful at reducing disputes between two fisheries. These successes indicate that more comprehensive zoning—that is, zones for fishing, recreational diving, and habitat protection, among other things—could alleviate other conflicts, beyond allocation.

**Lesson 3:
Gulf MPAs Do Not Reduce Fishing Effort**

The regulations establishing seven of the Gulf MPAs recognize excess effort as the primary problem, yet no established closure reduced effort. Managers repeatedly failed to recognize that, rather than reducing effort, MPAs inevitably displace it, whether spatially or temporally. If the shift is to a more vulnerable stock or location, the outcome can be problems in these other fisheries. Ignoring displaced effort can lead to significant misperceptions about how regulations should work (Wilens et al. 2002).

The Longline/Buoy Gear Exclusion Area provides an example of spatial displacement. Since implementation of the exclusion area, longline fishing for groupers has increased and populations have suffered serious decline (Schirripa and Legault 1999). At the same time, the absence of longliners in the MPA has not meant less effort there; it has simply allowed bandit-rig and recreational fishers to increase their overall effort within the MPA.

The Red Snapper Commercial and Recreational Seasonal Closures provide examples of temporal displacement. Effort is concentrated into shorter open seasons. In addition, fishers have shifted their effort to other species, including greater amberjack (*Seriola dumerili*), which is now overfished, and vermilion snapper (*Rhomboplites aurorubens*), which is approaching an overfished condition.

**Lesson 4:
MPA Performance Must Be Evaluated**

Monitoring is an essential component of effective management. It provides a means of measuring both environmentally-induced and management-induced changes in the system and of distinguishing between success and failure. Monitoring provides feedback to fishery managers and to fishers, effecting both improved management measures and convincing evidence of measure effectiveness. However, management must be both responsive to new information and flexible enough to incorporate that information into management strategies.

We found few MPA regulations that explicitly included performance evaluation as a condition of implementation and none that addressed adaptive management (Holling 1988; Hilborn and Walters 1992). NMFS monitored the Texas Closure and found increased yield and value in the brown-shrimp fishery, but some shrimpers claimed that increased costs associated with pulse fishing before and after the closure effectively offset any benefits of higher yield. Management has been unresponsive to information suggesting that redesigning the closure could eliminate the problem (Klima et al. 1986; Klima 1989; Griffin et al. 1993; Nance et al. 1994) and provide greater economic and ecosystem benefits.

**Lesson 5:
Compliance Is Crucial**

Many fishers will not willingly comply with regulations unless they perceive them as equitable, enforcement as fair, and the outcome as economically beneficial (Healey and Hennessey 1998; Jentofts 2000). Low levels of compliance require either higher levels of deterrence through increased fines or law enforcement presences, increased education of users to insure thorough understanding of the benefits, or, in some cases, restructuring of the regulation.

Due to the complexities of fisheries management plans and the number of regulations in place, the mission of federal fisheries law enforcement expands faster than workforce and fiscal resources allow. This chronic shortfall, coupled with changes in enforcement mission since the terrorist attacks on the United States in September 2001, has limited the overall enforcement presence offshore.

The use of vessel monitoring systems (VMS) could offset this problem. VMS, through satellite tracking of vessel position, can provide 90% or more compliance with areal boundaries, even among vessels fishing hundreds of miles from shore. Fishers may resent this “big brother” approach, but there is strong evidence in a number of fisheries that VMS has increased the profitability of the fishery by eliminating cumbersome regulations and improving compliance. For example, use of VMS on scallop vessels operating around an MPA on New England’s George’s Bank successfully stopped fishing and allowed a build-up of scallops that produced better fishery products (Murawski et al. 2000). VMS has

also been used successfully in the Hawaiian pelagic longline fishery and other U.S. fisheries (see www.nmfs.noaa.gov). VMS has been proven to save enforcement dollars spent patrolling offshore while providing enhanced safety at sea—the latter benefit being unequaled by other technologies. In short, it allows law enforcement to concentrate their resources directly on a problem offshore versus a mission covering large expanses of water in which no fishing activity occurs, such as an MPA.


In some cases, MPAs will clearly not be effective without widespread use of VMS. For example, NMFS recently overrode the Gulf Council decision to ban all fishing in the Madison-Swanson and Steamboat Lumps Marine Reserves by allowing continued fishing for highly migratory species within reserve boundaries (see *Coastal Conservation Association vs. Secretary of Commerce*, order of dismissal, Case No. 8:00CV1197-T-26E, June 7, 2001). This decision ignored Coast Guard and NMFS enforcement officials' concerns that allowing such fishing in otherwise closed areas complicated enforcement because of the difficulties in distinguishing between bottom and pelagic trolling, and thus between legal fishing and poaching. In this case, only if all fishing vessels operating in the vicinity of MPAs are required to use VMS can the Coast Guard and NMFS effectively detect violations. Indeed, law enforcement officials throughout the Southeast call MPAs that cannot be enforced "fisher-attractant devices" and "poacher havens."

Because enforcement as currently practiced is difficult, expensive, and sometimes simply not feasible, management agencies must devote more effort to increasing stake-holder buy-in, so as to increase voluntary compliance and decrease the need for deterrence. The process by which the Tortugas Ecological Reserve was established is an example.

Final Remarks

Fisheries management decisions are typically made during crises in a reactionary arena. Indeed, all of the MPAs established in the Gulf of Mexico save one—the Tortugas Ecological Reserve—have followed this pattern. Further, most of the MPAs established in the Gulf of Mexico to manage fisheries (with the exception of the Madison-

Swanson and Steamboat Lumps, which are currently under evaluation) have failed to solve the fishery problem identified by the Council. The mismatch between the problem and the regulation enacted is sometimes so severe that most decisions have served only to maintain a status quo decline in managed stocks. Despite this largely poor record, commercial fishers have supported fishery closures affecting their industry. Indeed, in our evaluations of MPAs of the Gulf of Mexico, we find that those MPAs designed with close input from the fishers affected (e.g., the shrimp closures, the Alabama Special Management Zones, the Tortugas Ecological Reserves) or that involve commercial fishers in the research (Madison-Swanson and Steamboat Lumps) show the highest level of understanding and support, even from those initially opposed to the closure (Neils 2003).

Some national recreational fishing organizations, on the other hand, largely oppose any closure that would limit their access to fishing opportunities (NRC 2001). The Coastal Conservation Association and Recreational Fishing Alliance, for instance, urge passage of the Freedom to Fish Act (www.joincca.org/html/positions/ffa2.htm), which would exempt recreational fishing from management that involves closed areas even though recreational fishing clearly contributes to overfishing throughout the Gulf of Mexico (Dayton et al. 2002) and has yet to be managed effectively. We see a recent positive trend in the way the Gulf Council has approached the use of MPAs and suggest that the Council maintain the use of MPAs as a management tool. Well-designed MPAs, especially no-take marine reserves, coupled with effective effort-management tools outside the MPAs hold tremendous potential to solve some management ills and to answer specific life history questions that are critical for effective stock assessment. We recommend that the Gulf Council reactivate its Marine Reserves Science and Statistics Committee and that this committee consider our evaluation of the spatial and seasonal closures now in use. We also strongly recommend that the Council look toward establishing MPAs that address two fishery concerns not yet addressed in the Gulf of Mexico: (1) empirical evaluation of the effects of fishing on habitat and (2) estimation of fishing and natural mortality rates essential for improving stock assessments. 

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