MARINE RESERVES TECHNICAL DOCUMENT

A SCOPING DOCUMENT FOR THE GULF OF MEXICO

JULY 1999

GULF OF MEXICO FISHERY MANAGEMENT COUNCIL
THE COMMONS AT RIVERGATE
3018 U.S. HIGHWAY 301 NORTH, SUITE 1000
TAMPA, FLORIDA 33619-2266
(813) 228-2815
FAX (813) 225-7015
e-mail: gulf.council@gulfcouncil.org

This is a publication of the Gulf of Mexico Fishery Management Council pursuant to National Oceanic and Atmospheric Award No. NA97FC0010

Table of Contents

INTRODUCTION

Purpose of This Document

The Gulf of Mexico Fishery Management Council is considering using marine reserves as a fisheries management tool in the federal waters of the Gulf of Mexico. Since marine reserves have not been used in this region and may be unfamiliar to those interested in Gulf of Mexico fisheries, this document is designed to provide relevant information to the Council and to the public, to introduce the concept of marine reserves, and to solicit public feedback. This document contains no specific proposals to establish marine reserves. A series of public workshops has been scheduled (see end of document for locations and dates) to present this information and to solicit input to help the Council decide how it might use marine reserves for fisheries management.

Problem Statement

Since the 1950's, fishery managers have tried to conserve stocks by limiting the amount of fish harvested (i.e. "total allowable catch") or by restricting fishermen's efforts (Beverton and Holt 1957). Unfortunately, these strategies are often. Problems result in part from difficulties in setting a safe harvesting level as well as from the expense of monitoring catches and controlling effort. Furthermore, if limiting total catch succeeds in enhancing a stock, any increased entry of fishermen into the fishery can diminish potential benefits. Even when the number of fishermen or boats is limited, improvements in fishing technology that increase fishermen's catch efficiency tend to negate any conservation benefits realized.

Measures intended to decrease fishing efficiency often can be sidestepped by fishermen. For example, trip limits are sidestepped by increasing the number of trips. Daily bag limits become ineffective if fishermen "high grade," or discard smaller fish when larger fish are caught subsequently. Size limits often leads to increases in undersized discards, unless capture of smaller individuals can be avoided. As a result of these limitations, the concept of creating areas permanently closed to fishing --"no-take marine reserves" -- is gaining attention (Roberts 1997; Bohnsack 1998). In some cases, protecting areas from fishing could be more effective and less obtrusive than other management approaches.

Overview

For our purposes, we define a marine reserve as a geographically defined space in the marine environment where special restrictions are applied to protect some aspect of the marine ecosystem (Allison et al 1998). Marine reserves can be designed to protect plants, animals, and natural habitats, or to preserve historical and cultural features in the marine environment.

Marine reserves are often called by different names, including marine protected areas, sanctuaries, parks, and fishery reserves. Marine reserves can provide a refuge for exploited species and improve ecosystem health by protecting biodiversity and habitats. Inside reserves, natural fish populations are larger and have a wider variety of age and size classes, compared to those in non-reserve areas. The direct benefits to fishermen may include transport of larvae and adult fish from the marine reserve to nearby fishing grounds (PDT 1990, Rowley 1992) and protection of genetic diversity. As a result of these benefits, the presence of marine reserves can decrease the chance of stock collapses and can accelerate recoveries if stocks are overfished. Thus, support for using no-take marine reserves together with other reasonable fishery management measures to halt the decline of fisheries in the Gulf of Mexico and elsewhere has gained the support of a growing number of fishermen, scientists, fishery managers, and environmentalists. Currently, however, few no-take marine reserves exist.

Vision Statement

Fishery resources provide food, jobs and recreational opportunities for millions. They are finite, but renewable. Thus, under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), a national fishery management program exists to promote domestic commercial and recreational fishing under sound conservation and management principles (Section 2(b)(3) MSFCMA). To achieve conservation and management goals while preventing overharvest, fishery managers set size limits, bag and trip limits, closed seasons, gear restrictions, and other measures. The data, the analyses, and the effects of these management measures are often subject to uncertainty.

Increasingly, fishery managers are looking for a strategy that can protect a large number of species while reducing the number of regulations even in the face of uncertainty. **Mandates to**

adopt both an ecosystem-level approach and to protect essential fish habitat make marine reserves particularly appealing to fishery managers. By "playing it safe", protecting a portion of a fished stock from exploitation may effectively circumvent the problem of uncertainty (Buckworth 1998).

Protection of marine habitats and ecosystems is essential to the well-being of fishery resources, as indicated by the Sustainable Fisheries Act of 1996 requirement that the Regional Management Councils identify essential fish habitat, adverse impacts on that habitat, and the actions that should be considered to conserve and enhance it.

In October 1998, the Gulf Council submitted to NMFS its “Generic Amendment for Addressing Essential Fish Habitat Requirements” (GMFMC 1998). To protect essential fish habitat, the amendment recommended closing areas to all fishing or to specific gear types during spawning, migration, foraging, and nursery activities; and designating marine protected areas to limit the adverse effects of fishing on vulnerable or rare areas, species, or life history stages. Marine reserves can play a major role in protection of habitat and marine ecosystem integrity.

QUESTIONS AND ANSWERS ABOUT MARINE RESERVES

What are the potential benefits and costs of marine reserves?

The benefits and costs of marine reserves are diverse. The Table below summarizes some of the benefits and costs suggested by those involved in the assessment of marine reserves. In addition to those listed below, more comprehensive lists of expected benefits have been compiled by others involved in marine reserve research (see Bohnsack 1998). In some cases, a particular concern may fit in both categories (e.g., enforcement). Each benefit and cost is addressed in greater detail in the remainder of this section.

Table 1. Marine Reserve Benefits and Costs

BENEFITS	COSTS
! Enhance commercial and recreational fishing S Build and maintain healthy fisheries S Provide insurance against uncertainty S Minimize regulations on fishing grounds S Improve traditional management ! Simplify enforcement S Violations easily detected S Easier for the public to understand ! Improve fairness and equity ! Preserve biodiversity through habitat protection ! Reduce direct and indirect fishing mortality ! Maintain wilderness areas for viewing natural ecosystems ! Enhance opportunities for the dive industry and tourism ! Provide educational opportunities ! Provide scientific research opportunities	! Foregone fishing opportunities ! Potential for higher costs ! Fishing-related benefits difficult to predict S Lag time before benefits achieved S Increased pressure on fishing grounds S Not appropriate for all fisheries S Difficult to site S Difficult to design S Cannot provide foolproof protection S Benefits may not accumulate ! Will not eliminate other fishery regulations ! Uncertainty of outcome ! Increased enforcement complexities S Direct enforcement necessary S Incentive for poaching created S Complexities may be created

BENEFITS:

<u>Enhance commercial and recreational fishing.</u>

Build and maintain healthy fisheries. Marine reserves may help build and maintain healthy fisheries in two primary ways. First, marine reserves may maintain or improve spawning stock biomass by protecting an abundance of large reproductive (fecund) individuals within its boundaries. The "protected" spawners could provide a more predictable supply of recruits to nearby fishing grounds. Second, fish emigrating from marine reserves could restock adjacent depleted fishing grounds. Larger individuals that wander out of the reserve may sustain trophy sport fisheries. A common feature of many successful fisheries is the presence of large space and time refuges, either implemented by managers or provided though a natural refuge that protects parts of the stock from fishing (Walters 1998).

Provide insurance against uncertainty. Marine reserves provide hedges against uncertainties, errors, and biases in fisheries management. In addition, marine reserves may be the best approach for fishery managers to implement the "precautionary approach" as mandated in the Food and Agriculture Organization's International Code of Conduct for Responsible Fisheries and adopted by the United States National Marine Fisheries Service. There may also be unanticipated benefits. For instance, the closure of areas in the northeast to the groundfish fishery resulted in an unanticipated benefit to the scallop stocks. In this case the abundance and individual size of scallops increased dramatically within the reserve, and there is evidence of significant spillover to non-reserve areas.

Minimize regulations on fishing grounds. With marine reserves in place, regulations on fishing activities outside of reserve boundaries may be less restrictive.

Improve traditional management. Marine reserves may enhance the effectiveness of traditional management measures in place on fishing grounds. First, marine reserves can help reduce problems that are inadvertently created under current management programs. For example, incidental catch of overexploited species, bycatch and release mortality, and selective removal of large, fecund fish is non-existent within reserve boundaries. Second, data collected from marine reserves can provide information to improve traditional management practices. For example, estimates of age, growth, natural mortality, and impacts of fishing can be determined more precisely from the more natural fish community that exists in the reserve.

<u>Simplify enforcement.</u>

Violators easily detected. A geographically restricted area where fishing and other activities are prohibited can be more easily targeted for enforcement. Surface or aerial surveillance can detect violators. Enforcement problems associated with measuring fish, identifying species, and examining fishing gear are eliminated within the restricted area.

Easier for the public to understand. The U.S. has a history of protecting wildlife in terrestrial reserves such as national parks. It is in this context that the concept of marine reserves may be most easily understood and accepted by the public.

Improve fairness and equity

Extraction of resources by any potential user is prohibited. No group is favored at the expense of another.

Preservation of biodiversity through habitat protection

Biodiversity refers to the types of species, their abundance, age classes, and their genetic qualities. It relates to ecosystem function by providing the fish harvested, their habitat, and their food. Preserving biodiversity with marine reserves involves protecting representative habitats and their associated communities throughout the Gulf. A series of small reserves in representative habitats would be an efficient approach to meeting this goal.

Reduce direct and indirect fishing mortality

Stock assessments for a number of reef species indicate that fishing mortality is high and increasing. Marine reserves established in areas that are presently fished or that have been historically fished and are now depleted can help reduce fishing mortality in the directed fishery. Marine reserves may also protect various life stages that are vulnerable to the indirect effects of fishing. For example, juveniles that occupy habitat impacted by fishing gear designed for other species could be protected by marine reserves. Red snapper juveniles taken as bycatch in shrimp trawls, or juveniles of other reef species taken in the deep-water hook-and-line fishery and discarded as undersized catch both comprise significant wastes of resources. Marine reserves located in areas of greatest juvenile density would provide significant protection.

Maintain wilderness areas for viewing natural ecosystems

Ecosystem structure and function are altered by the selective removal of organisms, particularly the removal of top predators, particularly vulnerable species, incidentally caught species (bycatch), and by the disturbance of habitat. Reserves afford the public and scientists the opportunity to study, appreciate and understand ecosystems in a state free of fishing, and thus to estimate the productivity of natural systems. The precautionary approach states without a complete understanding of ecosystems, some areas should be maintained in an undisturbed state. If terrestrial wilderness areas are appropriate for the public welfare, so too are they in the sea.

Enhance opportunities for the dive industry and tourism

The dive industry has become an important business in the Southeastern U.S. Tourist divers travel great distances to see underwater attractions such as jewfish and natural reef communities. Marine reserves providing such opportunities could be relatively small, on the scale of a single wreck or a single reef system.

Provide educational opportunities

Society can benefit considerably from the educational opportunities afforded by marine reserves. Public education includes primary and secondary education and educational opportunities for the general public. Graduate education especially needs undisturbed areas. Even fairly small reserves can provide considerable educational benefits.

Provide scientific research opportunities

Marine reserves, particularly those providing replicate sites, can serve many scientific purposes, including studies on the effects of fishing, studies on life history traits, and studies of other basic ecological processes. The results of these studies can be used to improve fishery models and management.

COSTS:

Foregone fishing opportunities

The creation of "no-fishing" zones may result initially in a temporary reduction in catches for those who have historically fished in the area of the reserve. These may be offset in the long run if reserve goals of increasing productivity outside of the reserve are realized.

Potential for higher costs

Depending on the size of a reserve and its distance from shore, fishermen displaced by marine reserves may have to travel greater distances to fish, thereby incurring additional costs. In addition, vessels may be required to be equipped with electronic vessel monitoring devices. Reserves will require increased at-sea manpower to patrol areas and assure compliance.

Fishing-related benefits may be difficult to predict.

Lag time before benefits achieved. In general, the more severe the overfishing before the marine reserve is established, the longer it will take for benefits to be achieved.

Increased pressure on fishing grounds. Fishing grounds near marine reserves may be fished more heavily by fishermen displaced by a reserve. There may also be increased competition among fishermen in non-reserve areas.

Not appropriate for all fisheries. Marine reserves are most appropriate for species that are relatively sedentary, such as snappers and groupers, or for species that have specific nursery sites, such as coastal sharks. Reserves are likely less appropriate for migratory species, such as mackerel, tuna and billfish.

Difficult to site. The optimum size, location, and number of reserves necessary to generate fishery benefits are difficult to determine. Also, discussion of marine reserves may elicit a "not in my backyard" response from the public, even among those who approve of the concept.

Difficult to design. Improper design of marine reserves may result in unanticipated emigration of species from the reserve to fishing grounds, reducing the reserve's effectiveness.

Cannot provide foolproof protection. Marine reserves, even with excellent siting and enforcement, cannot protect systems from all impacts. For example, they offer no protection from exotic species invasions or contamination by chemical spills.

Benefits may not accumulate. Improved catches resulting from marine reserves may attract new fishermen to the fishery, thus depriving the historical fishermen who made initial sacrifices. Controls, such as limited entry or individual transferable quotas, can ensure that these individuals benefit equitably.

Will not eliminate other fishery regulations

Marine reserves are an additional management tool and do not a substitute for, nor are they independent of, other fishing regulations. Marine reserves can serve as a buffer against overfishing, but the protection of juveniles and spawning aggregations, the reduction of bycatch mortality, and control of overall fishing mortality will still require traditional regulations, though perhaps to a less restrictive level.

Uncertainty of Outcome

Natural and human-induced factors could cause unanticipated outcomes in marine reserves. For example, a marine reserve placed where urban run off can harm the habitat, or where ships commonly traverse, may provide few benefits. Moreover, it is possible that the protected environment, once it "recovers," may not support the species expected, and may well unexpectedly support an alternative species. For example, when groundfish closures were implemented in the northeast, increased scallop production resulted.

Increased enforcement complexities

Direct enforcement necessary. At-sea enforcement or the use of electronic vessel monitoring devices is necessary to detect, apprehend, and discourage non-compliance in marine reserves. Reserves that are remote may be more difficult to enforce. However, the presence of non-consumptive users in reserves could aid enforcement by serving as extra eyes to report violators.

Incentive for poaching created. An incentive for deliberate poaching will be created if marine reserves produce larger, more numerous fish than in surrounding areas.

Regulatory complexities created. The regulations applied to a marine reserve may complicate enforcement if boats can enter the reserves. For example, can fish caught from grounds adjacent to the reserve be in a fisherman's possession inside the reserve boundaries? Can a fisherman have fishing gear on his boat inside the reserve? Can fishing vessels traverse the reserve? If restricted fishing or nonconsumptive activities are allowed inside the reserve, can the legal activities be readily differentiated from illegal fishing activities?

What are typical regulations for marine reserves?

Regulations to create marine reserves are fairly straightforward but will vary depending on the purposes for which the reserve is established. For example, commercial and recreational fishing and other extractive activities are prohibited in the no-take areas of the Florida Keys, Belize, the Philippines, and New Zealand. However, scientific research and non-consumptive recreational activities are permitted and encouraged (Ballantine 1995, FKNMS n.d., Gibson 1986, White 1988).

Buffer zones around marine reserves allow restricted consumptive activity. For example, buffers around marine reserves in the Philippines allow hook-and-line fishing, but restrict the more destructive techniques (e.g., dynamiting) commonly practiced in that country. In Belize, fishermen with a history of fishing in the area are licensed to fish in the buffer zone (Gibson 1986).

Where and why have marine reserves been established?

Marine reserves occur in over 30 countries and serve a variety of purposes (Shackell and Willison 1995) relating to local needs and economies. In some cases, no-take marine reserves have been established solely to enhance fisheries. In others, the primary purposes are unrelated to fisheries.

In the Philippines, as in many other parts of the world, fishing for food resulted in intense pressure on marine fisheries and the adoption of destructive fishing practices (Russ 1985, Castaneda and Miclat 1981). To counter this, marine reserves were created on the Sumilon, Apo, Balicasag, and Pamilacan islands with the intention of improving fishery yields, stopping habitat destruction, and preserving reefs for scientific research, education, aesthetics, recreation, and tourism (White 1986).

In Belize, a fishermen's cooperative established in the 1960's on the island of Ambergris Caye stimulated commercial fishing by providing stable markets, high prices for fish, and access to capital. Within a decade, the additional effort placed on fisheries caused a decline in local stocks. As fisheries declined, a small-scale tourist industry for sportfishing and SCUBA diving developed (Carter et al 1994). The goal for the Belize reserve, then, was to help sustain both fishing and tourism while protecting habitats for commercially important species and providing undisturbed areas to increase recruitment to adjacent areas (Gibson 1986).

In South Africa, fishing from the shore provides recreation and an inexpensive food source for many people. Fishing is also a major source of income for the coastal tourism and fishing tackle industries. Excessive exploitation, however, led to establishment of the De Hoop Nature Reserve and others to "protect depleted stocks in the hope that they would recover fully and attain levels that would result in restocking of adjacent areas" (Bennett and Attwood 1991:173).

In the U.S., no-take marine reserves have been established for the first time to protect fisheries. In the Florida Keys National Marine Sanctuary, a no-take marine reserve - the Western Sambos Ecological Reserve - was designed to "protect and enhance the spawning, nursery, or permanent homes of fish and other marine life" (FKNMS n.d.). Other no-take marine reserves are also being considered in Florida.

Only in New Zealand have marine reserves been created expressly to conserve the natural environment and to prohibit large-scale development. As a secondary objective, people are encouraged to visit and study the areas (Ballantine 1995). In Australia, concerns about oil and gas exploration and coral mining projects proposed for the Great Barrier Reef (GBR) led to the creation of the GBR Marine Park. This reserve uses a hierarchy of zones, ranging from general use to no-take. Some no-take areas allow only scientific research, prohibiting even recreation (GBRMPA 1989).

Another reason for marine reserves is to protect benthic habitat from the damaging effects of trawl and dredge gear. While virtually unstudied in the Gulf of Mexico, the evidence from the northeast and elsewhere in the world is compelling that trawled gear can have significant negative effects on benthic habitats and productivity (Brailovskaya 1998, Engel and Kvitek 1998, Kaiser 1998, Watling and Norse 1998). The only way to assess these effects is to create no-trawl zones. Such zones, in theory, could still allow hook-and-line fishing.

What have marine reserves accomplished?

The idea that marine reserves can build and maintain healthy fisheries is largely based on the following hypotheses:

- Spawning stock biomass will increase within the reserve boundaries;
- Larvae will be transported out of the reserve to replenish nearby fishing grounds;
- Some adults will migrate outside of reserve boundaries;
- Genetic diversity will be preserved.

Several studies suggest that no-take marine reserves support higher levels of spawning stock biomass than do non-reserve areas (Roweley 1992). Although spawning stock biomass is difficult to calculate directly, scientists compare the relative abundance, density, and size of fish between reserve and fished sites.

Studies conducted in the Philippines Sumilon Island marine reserve showed that mean biomass of heavily fished species like jacks, groupers, and snappers, increased within the reserve over time. Increases were relatively slow during the first five years, but were more rapid in the following four years. This suggests that gains in density and biomass within a marine reserve may reach a magnitude that provides fishery benefits in five to ten years (Russ and Alcala 1996a).

Further evidence is found in Saba Marine Park in the Netherland Antilles, where rapid increases in biomass occurred. This reserve, established in 1987, showed significant increases in biomass of most commercially important species within four or five years. The biomass of snapper increased by over 200 percent while the overall biomass of commercially important species increased by 60 percent (Roberts 1995). This pattern is repeated in Belize, South Africa, New Zealand and New Caledonia, where commercially valuable fish species were larger and more abundant in marine reserves than on nearby fishing grounds (Cole et al 1990, Bennet and Attwood 1991, Pulunin, and Roberts 1993, Wantiez et al 1997, Sedberry et al in press).

The second hypothesis, that the protected spawning stock biomass will supply larvae to nearby fishing grounds, is more difficult to measure, although some support is found on closed scallop grounds in the northeastern United States (Steve Murawski, in press). Clearly, fishing reduces the reproductive output of exploited species by removing large numbers of reproducing adults. Since marine reserves support spawning stock biomass and presumably high egg and larval production, they may also have the potential to increase recruitment into fisheries (Rowley 1992).

The third hypothesis, that adult fish will migrate out of the marine reserves to nearby fishing grounds, is supported by data (Rowley 1992). The best evidence for export of adult fish comes from Apo Island marine reserve in the Philippines where scientists determined that, after about nine years of protection and build-up of important species, local fishing grounds adjacent to the reserve began to be replenished (Russ and Alcala 1996b).

The Sumilon Island reserve in the Philippines provides another example of spillover. After ten years of protection, management broke down and unregulated fishing resumed. Scientists documented that fishermen's catch-per-unit-effort declined significantly. Subsequently, the reserve was reestablished and landings increased (Russ and Alcala 1996a). Thus, it appears that the marine reserve had been exporting fish to surrounding areas and supporting the higher catch rate (Alcala and Russ 1990). Interestingly, the local fishers acknowledged that they had been better off before the reserve was disbanded (White 1989).

What determines the size, number and location of marine reserves?

The optimum size, number and distribution of marine reserves required for a particular geographical area depends on the management. Goals are defined by society to optimize social benefits. For example, society may benefit by having increased fisheries production, maintaining biodiversity, protecting habitat, and creating educational, scientific, or diving opportunities. For some species, protection of a specific location, process, or size class alone may be sufficient to meet a goal. A much more extensive set of reserves designed to encompass a wide variety of habitats dispersed over a large geographic area (= reserve network) may be desirable for cases in which species occupy widely differing habitats during various life stages.

Gag, an important grouper in the Gulf of Mexico and south Atlantic regions of the U.S., illustrates these differences between life stage habitats of many marine species. (Different life stages use different habitats.) Gag spawn on shelf-edge reefs of east and west Florida. The eggs and larvae remain floating in the water column for about 40 - 50 days while drifting many miles with surface currents from spawning sites to distant estuarine nursery grounds. They then settle as juveniles, remaining in the estuary from late spring until early fall, when they travel to shallow reefs. Juveniles remain on shallow reefs until, at sexual maturity, they migrate with other adults to shelf-edge reefs for annual spawning in late winter and early spring. As adults, they occupy shallow-shelf to deep-shelf reef habitats. Thus, during the course of their lifetime, gag occupy virtually all structured habitats from the estuary to the shelf-edge.

Jewfish, a protected giant grouper, is another example. Adults spawn in aggregations on the shelf in water depths of 25 - 50 meters. After an extended larval period, juveniles settle in mangrove estuaries and may remain in the estuary for up to seven years before moving to the shallow reef environment. Clearly, any reserve designed to protect various life stages of marine species must take into account all habitats required in an organism's life cycle.

While there are a variety of possible designs for marine reserves, three basic forms stand out: a single small area, a single large area, or a network of areas. A small area might be chosen either to protect a specific unique habitat (e.g., Texas Flower Gardens) or a site-specific life-cycle event (e.g., mutton snapper spawning aggregations on Riley's Hump). A single large area might be chosen to protect habitat or nursery grounds from either fishing pressure or habitat destruction (e.g., the *Oculina* Banks). Alternatively, networks of reserves might be developed to maintain a variety of life stages for multi-species stocks. As discussed above, because of the diverse nature of the life stages of many marine species, a network of reserves might be more effective than a single large reserve in maintaining population stability and habitat integrity. Placing multiple reserves in a network can protect the diversity of habitats needed for each unique life stage.

How could marine reserves work in the Gulf of Mexico?

The following are case studies illustrating the use marine reserves for fishery management in the Gulf of Mexico.

Eastern Gulf of Mexico

Gag is an important grouper resource in the reef fish fishery of the Gulf of Mexico and the South Atlantic Bight. Like most groupers, gag have a complex reproductive style that involves sex change from female to male and the formation of spawning aggregations on shelf-edge reefs. These spawning aggregations are heavily targeted by fishermen. Over the last two decades, aggregation fishing has caused demographic and genetic consequences that inarguably could severely impact fishery production. The documented fishing-induced population changes include (1) a reduction in the proportion of males in the population from about 20 % in the late 1970's to the present 1 - 3%; (2) reduction in the size of spawners; (3) loss of spawning aggregations; and (4) genetic patterns that suggest high rates of inbreeding (i.e., the reproductive contribution is limited to very few individuals).

Which management approach is the most appropriate to insure that fishing does not interfere with the reproduction of this species? A closed season would presumably afford some protection. However, males remain associated with shelf-edge reefs in non-spawning times and thus are vulnerable to fishing year-round. With a closed season, the proportion of males could remain depressed, while other species on the same shelf-edge reefs whose spawning seasons do not coincide with that of gag (e.g., scamp, gray snapper, red snapper, and red grouper) would be heavily targeted at the end of the closed season. (It is worthwhile to note that scamp showed similar demographic changes as gag (Coleman et al. 1996)). On the other hand, if marine reserves with year-round closures were used to manage gag, they would protect the gag spawning aggregations, the spawners of other species, the spawning habitat, and provide year-round protection to gag males/females that remain on shelf-edge reefs.

Habitat can be severely damaged by certain fishing practices. An example of formerly productive habitat that was destroyed throughout most of its range is the *Oculina* Banks off the east coast of Florida. This habitat with associated limestone pinnacles and ridges is composed chiefly of the branching ivory tree coral *Oculina varicosa*. This habitat was described for the first time by researchers from the Harbor Branch Oceanographic Institute (HBOI), Ft. Pierce in the late 1970's. At that time gag and scamp spawning aggregations were abundant and other important reef fish species were also associated with the intact *Oculina* habitat. Researchers also noted considerable habitat damage on the *Oculina* Banks. In response to the HBOI researcher's observations, the South Atlantic Fishery Management Council designated a 92 square nautical mile area of the *Oculina* Banks a habitat area of particular concern (HAPC) and prohibited trawling and dredging in the area. In 1994, the HAPC was closed to all bottom fishing and designated as an experimental marine fishery reserve. This designation came in response to studies in the Gulf by Florida State University (FSU) and NMFS researchers that demonstrated demographic changes in gag and scamp populations resulting from heavy fishing on the spawning aggregations of both species. A submersible survey done in 1995 by FSU, NMFS and HBOI researchers indicated that habitat damage was more extensive than that observed in the late 1970's. The evidence suggests that trawling and dredging activities (for rock shrimp and scallops) caused the coral habitat destruction. Restoration experiments and studies of the reproductive biology of *Oculina* by FSU, NMFS, and HBOI researchers now underway will be used to direct restoration of the habitat.

<u>Artificial Reefs as Marine Reserves</u>

Natural hard substrate is not common on the relatively flat, soft floor of the northwestern Gulf of Mexico continental shelf. Natural hard substrate habitat exists as small, low relief near-shore outcrops and occasional mid-shelf banks off southern Texas and widely scattered shelf-edge and upper slope banks off the Texas-Louisiana border (Rezak et al. 1985). The fact that red snapper need hard substrate as essential habitat, combined with the large number of aging oil and gas platforms in the Gulf soon to need removal, makes creation of artificial reef marine reserves in the western Gulf of Mexico worth considering.

There are over 5000 oil and gas platforms in the Gulf of Mexico, the vast majority of which exist off Texas and Louisiana in the northwestern Gulf. Estimates suggest that these platforms have increased the hard substrate in the Gulf by as much as 28% (Scarborough-Bull and Kendall 1992). Federal regulations currently require removal of decommissioned platforms or allow their conversion to artificial reefs. Since as many as 100 platforms are removed from the Gulf each year (Ditton and Folk 1981, Scarborough-Bull and Kendall 1994, Culbertson et al. 1996, Reggio 1996), the opportunity exists for creating one or more, substantially sized artificial reef reserves. Mutual benefits of this concept include:

1) utilization of numerous platforms could be an economic benefit to industry;
2) the existing platform habitat would not be lost;
3) the limited natural hard substrate habitat would not be removed from the fishing industry; and
4) a large, highly complex artificial reef would be of benefit to many non-commercial, yet ecologically important species

Parameters for the artificial reef reserve would include a large number of platforms in a single or possibly several areas, for instance, inner, mid, and outer continental shelf. Although shipping/navigation requirements necessitate platforms be positioned below 80 feet in depth, ecologically it would be more beneficial if the structures could extend near the water's surface to allow for optimum growth of fouling biomass in the upper sunlit zones.

Other questions to consider concerning artificial reef establishment include: should platform placement be near natural hard substrates; should additional soft bottom adjacent to the artificial reef be set aside, since red snapper utilize a variety of habitats during different life stages (Bradley and Bryan, 1973); could mariculture cages be suspended from adjacent upright platforms, allowing release and enhancement of stocks?

Although artificial reef marine reserves could be used to replace artificial habitat lost due to platform removal, using artificial reef reserves as a substitute for natural reef reserves is more problematic. Creating artificial reef marine reserves has been suggested as a way to obtain the benefits of marine reserves while avoiding the social and economic disruption that might occur from closing existing fishing grounds. In general, artificial reefs suffer several fundamental problems that make them less desirable for marine reserves than natural habitat. 1. The amount of habitat that can be reasonably built by creating new artificial reefs for use as reserves is a 'drop in the ocean' compared to the amount of natural habitat. 2. The assemblage of organisms at artificial reefs is not natural and unlikely to be representative of biodiversity, at least initially. Eventually, ecological succession determines the natural assemblage of every habitat, and could eventually allow for the possibility of greater diversity of biological assemblages, but such succession would occur relatively slowly. 3. Species attracted to artificial reefs may be spawning in the wrong place for optimum survival and dispersal. Too often, artificial reef sites are chosen by chance, convenience, economics, and/or politics. Artificial reef sites should be chosen on ecological/biological merit. 4. For species that utilize artificial reefs, the cost of providing sufficient habitat would be prohibitive and the process too slow to deal with immediate problems, particularly for species that are relatively sedentary and would recruit slowly to the reefs.

Research at Texas A&M University - Corpus Christi strongly indicates that artificial reefs do increase biomass in the Gulf of Mexico when one considers those non-harvested species of invertebrates, finfish, and the algae growing on artificial reefs which are all key elements in the ecosystem dynamics of the Gulf (personal communication from Quenton Dokken, TAMUCC). Therefore, |artificial reef reserves may be appropriate in combination with natural reef reserves, but not as a substitute for the inclusion of natural reef areas. We simply do not have adequately definitive databases and knowledge of the reef dynamics (artificial versus natural) to support such a strategy.

Finally, because of the complexities of ecosystem structure and function, it may be more useful to use the artificial habitats as fishing sites while retaining natural sites as marine reserves. Since productivity is a prime concern and the question of artificial reefs as production or attraction zones remains unanswered, the precautionary approach would dictate that natural sites should be considered first.

What criteria should be used in establishing and evaluating marine reserves?

Discussions of the objectives and criteria for selecting marine reserves often overlook the many benefits of establishing such areas. Their benefits reach far beyond fisheries management and biodiversity maintenance to include protection for ecosystem structure and function, improving non-consumptive opportunities, improving fishery yields, and increasing knowledge and understanding of marine systems.

Marine Reserves as a Management Tool

Marine reserves as fisheries management tools must have clearly defined goals, objectives, and criteria.

The goals of marine reserves are:

- Protect and preserve habitat and ecosystems that are important for maintaining natural resources and ecosystem functions;
- Enhance the sustainability of exploited fishery resources; and
- Provide a risk-averse means of protecting resources and habitat in the face of uncertainty.

The objectives necessary to achieve these goals are:

- Reduce stresses to the ecosystem and habitat from human activities;
- Protect biological diversity and the quality of resources;
- Protect and enhance fisheries resources;
- Protect critical/sensitive habitats;
- Provide concentrated harvests of marine organisms for dispersal;
- Provide undisturbed monitoring sites for research activities; and
- Prevent heavy concentrations of uses that degrade fishery resources.

Marine Reserve Criteria

The following criteria for establishing effective Marine Ecological Reserves are taken from several sources (Bohnsack, 19--; FKNMS Management Plan 1996; and B. Ballantine, 1996), and serve as the starting point for creating criteria for the establishment of marine reserves in federal waters of the Gulf of Mexico. Not all of these criteria are applicable to offshore marine reserves in federal waters.

Public Considerations Criteria

1. Marine Reserves must be created on the principle of protecting the long-term public interest.
2. 'No-take' marine reserves are the most acceptable and practical means of protecting public interests. Limited-use marine reserves become publicly unacceptable if they fail to support any general principle while creating new sectional interests and increasing user conflicts.
3. Marine reserves should protect all species from exploitation.
4. Non-extractive uses may or may not be encouraged in 'no-take' areas. However, public access should be encouraged as it supports compliance and understanding of management.

Ecosystem and Design Criteria

5. Marine reserves should include representation of all marine habitats in every biological region.

6. Replication is essential.

7. A network design is preferred for optimal benefits to accrue.

8. The number and size of marine reserves should be set at the minimum level of protection that is self-sustaining.

9. Marine reserves should be created independently of regulations on individual species required by exploitive activities.

10. Borders should be simple, following latitude-longitude lines.

Location Criteria

11. The general design should be determined by marine topography.

12. Marine reserve locations should consider known dispersal patterns (sources and sinks) of species to be protected.

13. Marine reserve locations should consider water circulation patterns and the potential for larval dispersal.

14. Marine reserve locations should avoid areas with pollution and sedimentation.

In addition to the above criteria, and in keeping with any other fishery regulation in federal waters, marine reserves must comply with the ten National Standards for Fishery Conservation and Management listed in the Magnuson-Stevens Fishery Conservation and Management Act Criteria (Appendix 1).

Whether the objective is to protect the ecological integrity of an area or to enhance successful spawning, the use of marine reserves can result in positive outcomes that meet multiple objectives.

Generally speaking, the design of marine reserves for fisheries management using the above criteria will result in protection for the ecological integrity of an area.

What legal authority does the Gulf Council have to establish marine reserves?

The Magnuson-Stevens Fishery Conservation and Management Act, Section 303, Contents of Fishery Management Plans, subsection b, provides the legal authority of the Gulf Council to establish marine reserves. It states, in pertinent part, "Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, may:.

- designate zones where, and periods when, fishing shall be limited, or shall not be permitted, or shall be permitted only by specified types of fishing vessels or with specified types and quantities of fishing gear;
- prescribe such other measures, requirements, or conditions and restrictions as are determined to be necessary and appropriate for the conservation and management of the fishery.

These provisions grant the Gulf Council the authority to include marine reserves within fishery management plans and provide for the associated regulations and restrictions necessary to implement such marine reserves.

What process would be used to choose areas for marine reserves?

Fishery regulations, including marine reserves, can be implemented by either a plan amendment to the Reef Fish Fishery Management Plan (or other appropriate management plan) or by establishing a framework procedure to implement a regulatory amendment. A framework procedure is the preferred method, since it assures that a specific sequence of events is followed before a decision to establish or modify a marine reserve is made.

The Reef Fish Fishery Management Plan currently has two framework procedures, one for setting total allowable catch (TAC) and the fishing regulations needed to keep the fishery within the TAC, and one for establishing special management zones. Both of these procedures contain provisions for establishing restricted fishing areas, but for specific purposes, either to protect a specific species or to promote the use of an area, usually an artificial reef, in a particular way. One possible format for a marine reserves framework procedure could be as follows. This draft procedure is modified from the framework procedure for establishing special management zones.

DRAFT FRAMEWORK PROCEDURE FOR ESTABLISHING MARINE RESERVES

Upon request to the Council from a Council member, from the National Marine Fisheries Service, from a fishing or conservation organization or other interested party, or upon recommendation of a Council advisory panel, scientific and statistical committee, or stock assessment panel for the establishment of a marine reserve or network of marine reserves, or for modification/termination of an existing marine reserve or network of reserves, an area of consideration may be designated (or modified/terminated) as a Marine Reserve, with rules that prohibit or regulate the use of specific types of fishing gear or fishing activities that are not compatible with protecting the sustainability and biodiversity of marine resources in the Gulf of Mexico. This may be done by regulatory amendment under the following criteria and procedure:

1. A Marine Reserves Assessment Panel will evaluate the request in accordance with the following criteria and prepare a report on the suitability of the request:

   a. Protects the long-term public interest
   b. Promotes conservation of the resource.
   c. Includes representative marine habitats.
   d. Is self-sustainable.
   e. Considers the impacts on historical uses.
   f. Considers the environmental impacts and cumulative impacts on the marine resources.
   g. Considers fairness and equity of proposed marine reserve.
   h. The precise location of the proposed marine reserve and its designation as either a no-take reserve or limited use reserve (with appropriate fishing regulations) should be indicated.

2. The appropriate Advisory Panel (AP) and/or Scientific and Statistical Committee (SSC) will review the report and associated documents and advise the Council. The Council Chairman may schedule meetings of the SSC and AP for this purpose. The Council Chairman will also schedule public hearings in the area affected.

3. The Council, following review of the Marine Reserve Assessment Panel's report; supporting data; the SSC, AP, and public comments; and other relevant information, may recommend to the Southeast Regional Administrator of the National Marine Fisheries Service (RA) that a marine

reserve or network of marine reserves, as either no-take reserves or with appropriate proposed rules on fishing be approved. Such a recommendation will be accompanied by all relevant background data.

4. The RA will review the Council's recommendation, and if he concurs in the recommendation, will propose regulations in accordance with the recommendations. He may also reject the recommendation, providing written reasons for rejection.

5. If the RA concurs in the Council's recommendations, he shall publish proposed regulations in the *Federal Register* and shall afford a reasonable period for public comment which is consistent with the urgency of the need to implement the management measure(s).

LIST OF PREPARERS

This document was written by an Ad Hoc Marine Reserves Scientific and Statistical Committee along with Council and Council staff during late 1998 and early 1999. Members of the Committee and other contributors are as follows:

Ad Hoc Marine Reserves Scientific and Statistical Committee

Dr. J. Walter Milon, Chair	University of Florida
Ms. Pamela B. Baker, Vice-Chair	Environmental Defense Fund
Dr. James Bohnsack	NMFS/SEFSC
Mr. Billy D. Causey	Florida Keys National Marine Sanctuary
Dr. Peter Colosi	NMFS Northeast Regional Office
Dr. Christopher C. Koenig	Florida State University
Dr. Don R. Levitan	Florida State University
Mr. Eugene Proulx	NMFS Southeast Enforcement Division
Dr. Stephen Thomas	University of South Alabama
Dr. John W. Tunnel, Jr.	Texas A&M University - Corpus Christi
Dr. Frederick C. Whitrock	Assistant Attorney General, Louisiana

Other Contributors

Dr. Felicia Coleman	Member, Gulf Council
Mr. Steven Atran	Biologist, Gulf Council

SCOPING WORKSHOP LOCATIONS AND DATES

Scoping workshops are scheduled from 7:00 p.m. to 10:00 p.m. at the following dates and locations.

Monday, August 9, 1999
Four Points Sheraton
3777 North Expressway
Brownsville, Texas 78526

Tuesday, August 10, 1999
Ellis Memorial Library
700 West Avenue A
Port Aransas, Texas 78373

Wednesday, August 11, 1999
Texas A&M University Auditorium
200 Seawolf Parkway
Galveston, Texas 77553

Thursday, August 12, 1999
Four Points Sheraton
333 Poydras Street
New Orleans, Louisiana 70130

Monday, August 16, 1999
J. L. Scott Marine Education Center & Aquarium
115 East Beach Boulevard
Biloxi, Mississippi 39566

Tuesday, August 17, 1999
Hilton Beachfront Garden Inn
23092 Perdido Beach Boulevard
Orange Beach, Alabama 36561

Wednesday, August 18, 1999
The Boardwalk Beach and
Conference Center
9600 South Thomas Drive
Panama City Beach, Florida 32408

Thursday, August 19, 1999
Steinhatchee Elementary School
1st Avenue South
Steinhatchee, Florida 32359

Monday, August 23, 1999
Harvey Government Center
1200 Truman Avenue
Key West, Florida 33040

Tuesday, August 24, 1999
Radisson Bay Harbor Inn
7700 Courtney Campbell Causeway
Tampa, Florida 33607

REFERENCES

Alcala, A.C. and G.R. Russ. 1990. A direct test of the effects of protective management on abundance and yield of tropical marine resources. J. Const. Int. Explor. Mer. 46:40-47.

Allison, G.W., J. Lubchenco, and M.H. Carr. 1998. Marine reserves are necessary but not sufficient for marine conservation. Ecological Applications (Supplement). 8(1):579-592.

Ballantine, W.J. 1995. Networks of "no-take" marine reserves are practical and necessary. In Shackell, N.L. and J.H. Martin Willison. 1995. Marine Protected Areas and Sustainable Fisheries. Proceedings of the symposium on marine protected areas and sustainable fisheries conducted at the Second International Conference on Science and the Management of Protected Areas. Dalhousie University, Halifax, Nova Scotia, Canada, May 16-20, 1994. pp. 13-20.

Bennet, B.A. and C.G. Attwood. 1991. Evidence for recovery of a surf-zone fish assemblage following the establishment of a marine reserve on the southern coast of South Africa. Marine Ecology Progressive Series. 75:173-181.

Beverton, R.J.H. and S.J. Holt. 1957. On the dynamics of exploited fish populations. [1993 reprint of the 1957 edition] Chapman & Hall, London.

Boehlert, G.W. 1996. Biodiversity and the sustainability of marine fisheries. Oceanogr. 9: 28-35.

Bohnsack, J.A. 1998. Application of marine reserves to reef fisheries management. Aust. J. Ecol. 23: 298-304.

Bohnsack, J.A. 1994. How marine fishery reserves can improve reef fisheries. In Proceedings of the 43rd Gulf and Caribbean Fisheries Institute. 43:217-241.

Bohnsack, J.A. and J.S. Ault. 1996. Management strategies to conserve marine biodiversity. Oceanogr. 9: 73-82.

Buckworth, R.C. 1998. World fisheries are in crisis? We must respond! p. 3-17 *In* Pitcher, T.J., P.J.B. Hart, and D. Pauly [Eds.] Reinventing Fisheries Management. Klower Academic Publishers, Norwell, MA. 435 p.

Bradley, E., and C.E. Bryan. 1973. Northwestern Gulf of Mexico marine fisheries investigations - Study No. 2. NMFS, St. Petersburg, Fl. 65 pp.

Brailovskaya, T. 1998. Obstacles to protecting marine biodiversity through marine wilderness preservation: examples from the New England region. Conservation Biology 12(6):1236-1240.

Buxton, C.D. 1993. Life-history changes in exploited reef fishes on the east coast of South Africa.. Env. Biol. Fish. 36: 47-63.

Carter, J., J. Gibson, A. Carr III, and J. Azueta. 1994. Creation of the Hol Chan Marine Reserve in Belize: A "grass roots" approach to barrier reef conservation. Environmental Professional. 16(3):220-231.

Castaneda, P.G. and R.I. Miclat. 1981. The municipal coral reef park in the Philippines. In Proceedings of the Fourth International Coral Reef Symposium. Manila, Philippines. 1:283-285.

Culbertson, J.C., H. Osborn, and D. Peter. 1996. Texas artificial reef development program. Pages 19-22. Proceedings: Sixteenth Annual Gulf of Mexico Information Transfer Meeting. OCS Study MMS 97-0038. New Orleans U.S. Department of the Interior. Minerals Management Service. Gulf of Mexico OCS Regional Office.

Dayton, P.K., S.F. Thrush, M.T. Agardy, and R.J. Hofman. 1995. Environmental effects of marine fishing. Aquatic Conserv.5: 305-232.

Ditton, R.B., and J.M. Falk. 1981. Obsolete petroleum platforms as artificial reef material. Pages 96-105 in D.Y. Aska, ed. Artificial Reefs: Conference Proceedings. Florida Sea Grant. Report Number 41.

Drake, M.T., J.E. Claussen, D.P. Philipp, and D. L. Pereira. 1997. A comparison of bluegill reproduction strategies and growth among lakes with different fishing intensities. N. Am. J. Fish. Manag. 17: 496-507.

Engel, J. and R. Kvitek. 1998. Effects of otter trawling on a benthic community in Monterey Bay National Marine Sanctuary. Conservation Biology 12(6):1204-1214.

FKNMS (Florida Keys National Marine Sanctuary). No date. Florida Keys National Marine Sanctuary. Brochure providing an overview of the Sanctuary plan.

Gibson J. 1986. Hol Chan Marine Reserve Draft Management Plan. Belize Fisheries Unit. Belize City, Belize.

GBRMPA (Great Barrier Reef Marine Park Authority). 1989. Annual Report 1988-1989. Townsville, Queensland: Great Barrier Reef Marine Park Authority. 100 pp.

GMFMC. 1998. Generic Amendment for Addressing Essential Fish Habitat Requirements in the Following Fishery Management Plans of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 238 p. + appendices.

GuDAnette, S., T. Lauck, and C. Clark. 1998. Marine reserves: from Beverton and Holt to the present. Rev. Fish. Biol. & Fisheries 8: 1-21.

Kaiser, M.J. 1998. Significance of bottom-fishing disturbance. Conservation Biology 12(6):1230-1245.

Lauck, T., C.W. Clark, M. Mangel and G.R. Munro. 1998. Implementing the precautionary principles in fisheries management through marine reserves. Ecological Applications (Supplement). 8(1):S72 - S78.

Ludwig, D., R. Hilborn and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: Lessons from history. Science 260: 17-18.

Malakof, D. 1997. Extinction on the high Seas. Science 277: 486-488.

Murawski, S. in press. [...] Bulletin of Marine Science.

Pauly, D. 1997. Points of view: Putting fisheries management back in places. Rev. Fish Biol. Fisheries 7:125-.

Pauley, D, V. Christensen, J. Dalsgaard, R. Forese, F. Torres, Jr. 1998. Fishing down marine food webs. Science 279: 860-863.

Plan Development Team. 1990. The potential of marine fishery reserves for reef fish management in the U.S. Southern Atlantic. NOAA Technical Memorandum NMFS-SEFC-261. 40 pp.

Plan Development Team. 1990. The potential of marine fishery reserves for reef fish management in the U.S. southern Atlantic. Snapper-Grouper Plan Development Team Report for the South Atlantic Fishery Management Council. NOAA Technical Memorandum NMFS-SEFC-261. 45 p.

Pulunin, N.V.C. and C.M. Roberts. 1993. Greater biomass and value of target coral-reef fishes in two small Caribbean marine reserves. Marine Ecology Progress Series. 100(1-2):167-176.

Reggio Jr., N.C. 1996. Decommissioning and artificial reef development. Pages 3-4. Proceedings: Sixteenth Annual Gulf of Mexico Information Transfer Meeting. OCS Study MMS 97-0038. New Orleans: U.S. Department of the Interior. Minerals Management Service. Gulf of Mexico OCS Regional Office.

Rezak, R., T.J. Bright, and D.W. McGrail. 1985. Reefs and banks of the northwestern Gulf of Mexico: their geological, biological, and physical dynamics. John Wiley and Sons, New York. 259 pp.

Ricker, W.E. 1981. Changes in the average size and average age of Pacific salmon. Can. J. Fish. Aquat. Sci. 38: 1636-1656.

Roberts, C.M. 1997. Ecological advice for the global fisheries crisis. Trends Ecol. Evol. 12(1): 35-38.

Roberts, C.M. 1995. Rapid build-up of fish biomass in a Caribbean marine reserve. Conservation Biology. 9(4):816-826.

Roberts, C.M. 1994. Marine reserves: A brief guide for decision-makers and users. Presented at the Workshop on Coastal and Ocean Resource Management. NGO Islands Forum, UN Global Conference on the Sustainable Development of Small Island Developing States, Barbados, April 25. 12 pp.

Rowley, R.J. 1992. Impacts of marine reserves on fisheries: a report and review of the literature. Wellington, New Zealand. Department of Conservation. 50 pp.

Russ, G.R. 1985. Effects of protective management on coral reef fishes in the central Philippines. In Proceedings of the Fifth International Coral Reef Congress. Tahiti. 4:219-224.

Russ, G.R. and A.C. Alcala. 1996a. Marine reserves: Rates and patterns of recovery and decline in abundance of large predatory fish. Ecological Applications. 6(3):947-961.

Russ, G.R. and A.C. Alcala. 1996b. Do marine reserves export adult fish biomass? Evidence from Apo Island, Central Philippines. Marine Ecology Progress Series. 132:1-9.

Samoilys, M.A. 1988. Abundance and species richness of coral reef fish on the Kenyan Coast The effects of protective management and fishing. In Proceedings of the 6th International Coral Reef Symposium. Australia. 2:261-266.

Scarborough-Bull, A., and J.J. Kendall, Jr. 1992. Preliminary investigation: platform removal and associated biota. Pages 31-37 in L.B. Cahoon, ed. Proceedings of the American Academy of Underwater Sciences Twelfth Annual Scientific Diving Symposium. University of North Carolina Sea Grant College Program. September 24-27, 1992.

Scarborough-Bull, A., and J.J. Kendall, Jr. 1994. An indication of the process: offshore platforms as artificial reefs in the Gulf of Mexico. Bulletin of Marine Science. 55(2-3): 1086-1098.

Sedberry, G.R., J. Carter and P.A. Barrick. In press. A comparison of fish communities between protected and unprotected areas of the Belize reef ecosystem: Implications for conservation and management. In Proceedings of the 45th Gulf and Caribbean Fisheries Institute Meeting. 25 pp.

Shackell, N.L. and J.H. Martin Willison. 1995. Marine Protected Areas and Sustainable Fisheries. Proceedings of the symposium on marine protected areas and sustainable fisheries conducted at the Second International Conference on Science and the Management of Protected Areas. Dalhousie University, Halifax, Nova Scotia, Canada, May 16-20, 1994. 294 pp.

Smith, P.J., R.I.C.C. Francis, and M. McVeagh. 1991. Loss of genetic diversity due to fishing pressure. Fish. Res. 10: 309-316.

Walters, C. 1998. Designing fisheries management systems that do not depend upon accurate stock assessment. p. 279-288 *In* Pitcher, T.J., P.J.B. Hart, and D. Pauly [Eds.] Reinventing Fisheries Management. Klower Academic Publishers, Norwell, MA. 435 p.

Wantiez, L., P. Thollot, and M. Kulbicki. 1997. Effects of marine reserves on coral reef fish communities from five islands in New Caledonia. Coral Reefs. 16(4):215-224.

Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12(6):1280-1297.

White, A.T. 1989. Two community-based marine reserves: lessons for coastal management p. 85-96. In Chua, T.E. and D. Pauly (eds.). ICLARM Conference Proceedings. Coastal Area Management in Southeast Asia: Policies, Management Strategies and Case Studies. 254 pp.

White, A.T. 1988. The effect of community-managed marine reserves in the Philippines on their associated coral reef fish populations. Asian Fisheries Science. 2:27-41.

White, A.T. 1986. Marine reserves: How effective as management strategies for Philippine, Indonesian and Malaysian coral reef environments? Ocean Management. 10:137-159.

Wilson, D.S. and A.B. Clark. 1996. The shy and the bold. Nat. Hist. 96(9):26-28.

APPENDIX 1. MAGNUSON-STEVENS ACT NATIONAL STANDARDS

With the 1996 reauthorization of the Magnuson Act (now called the Magnuson-Stevens Act), three new national standards were added to the previous seven standards for fishery conservation and management. In addition, standard number 5 underwent some rewording (the word promote was replaced with consider). The ten national standards are as follows (Section 301(a) (16 U.S.C. 1851(a))):

(1) Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

(2) Conservation and management measures shall be based upon the best scientific information available.

(3) To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

(4) Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

(5) Conservation and management measures shall, where practicable, consider efficiency in the utilization of the resources; except that no such measure shall have economic allocation as its sole purpose.

(6) Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

(7) Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

(8) Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.

(9) Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

(10) Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

MR-TechScope.wpd