No Take Marine Protected Areas (nMPAs) as a fishery management tool, a pragmatic perspective

A Report to the FishAmerica Foundation

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Executive Summary

Marine Protected Areas (MPAs) are portions of the marine environment which are protected from some or all human activity. Often these are proposed as a safeguard against collapse of fish stocks, although there are numerous other suggested purposes for their establishment. "No take" MPAs (hereafter referenced as nMPAs) are those from which no harvest is allowed. Other types include those where certain types of harvest are prohibited, which are reserved for certain user groups, or which are protected from other human activities such as drilling or dredging.

Establishment of nMPAs may have numerous beneficial purposes. However, as a tool for fisheries management, where optimal and/or maximum sustainable yield is the objective, nMPAs are generally not as effective as traditional management measures, and are not appropriate for the vast majority of marine species. This is because most marine species are far too mobile to remain within an nMPA and/or are not overfished. For those few species that could receive benefit, creation of nMPAs would have an adverse effect on optimal management of sympatric forms.

Eight percent of US fish stocks of the Exclusive Economic Zone (EEZ) are reported to be experiencing overfishing. The finfish stocks included in this number are primarily pelagic or highly mobile species, movement patterns that don't lend themselves to benefit from nMPAs. Thus a very small percentage, something less than 2 %, depending on mobility potentials, is likely to benefit from creation of these no-take zones. However, many of these species have come under management within the last decade, employing more traditional fishery management measures, and are experiencing recovery.

MPAs (both "no take" and other types) can serve a positive function as a management tool in protecting breeding aggregations, in helping recovery of severely overfished and unmanaged insular fish populations with little connectivity to adjacent stocks, and in protecting critical habitat which can be damaged by certain fishing methods.

Introduction

Concept of MPAs

In recent years, a great deal of interest has been expressed in the establishment of Marine Protected Areas (MPAs), marine "no take" areas, or marine sanctuaries (e.g. National Research Council: "Marine Protected Areas: Tools for Sustaining Ocean Ecosystems, 2001; National Resource Defense Council: "Keeping Oceans Wild: How marine reserves protect our living seas, 2001") This interest has been spurred by the frequent references to depleted fish stocks, and continued decline in marine fishery resources.

Proponents of so called "no take" Marine Protected Areas (nMPAs) have described the benefits to include potential as a fishery management tool as well as several other related advantages, specifically, conserving biodiversity, protecting (coastal) ecosystem integrity, preserving cultural heritage, providing educational and recreational opportunities, and establishing sites for scientific research (Houde et al., 2001). In addition, other benefits suggested include enhancing ecotourism, and reducing user group conflict (e.g. divers and harvesters).

The concept of nMPAs is initially attractive, and will no doubt elicit a great deal of support and discussion among various groups interested in protecting marine habitats. However, the many offered benefits described above often overlap, and become intertwined in the discussions that ensue. <u>A fishery management tool is one that sustains and/or increases through time the yield of a fish stock, or several sympatric stocks of an ecosystem.</u> If nMPAs are to be considered as a management tool, then that goal or objective, sustained and/or increased yield, needs to be clearly stated, and distinguished from other, more theoretical goals.

Traditional Management Tools

Traditional management tools generally focus on reducing effort, enhancing stocks from hatchery operations, and protecting critical habitat. Effort reduction includes bag and size limits (including sometimes slot limits), quotas, seasonal and/or areal closures, gear restrictions, and by-catch reduction. These have been successful for more than a century in freshwater environments. Their use in marine habitats has only become widespread in the United States in recent decades, especially since passage of the Fishery Conservation and Management Act in 1976. Hatchery operations and stocking have also been primarily a freshwater endeavor, although recent efforts to stock some marine species have been attempted and yet to be evaluated over the long term. Protection of critical marine habitats has become an issue of extreme concern and is the focus of current efforts on the part of all Fishery Management Councils, as required in the most recent reauthorization of the Sustainable Fisheries Act. Use of MPAs for this purpose is discussed later in this paper.

Purposes of MPAs

In order for nMPAs to function as a management tool for marine fisheries, there needs to be an examination in specific instances and with specific stocks to determine the potential benefits. This is especially true when stakeholders are currently so involved in management decisions that impact their livelihood. In their work on no-take reserves (Murray et al., 1999), the authors list guidelines for these reserves, including first:

1. Reserves should have clearly identified goals, objectives, and expectations.

> **a) Clearly identify and describe the purposes of each reserve.**
> **b) Clearly identify the species, communities, and habitats to be protected.**
> **c) Clearly identify the projected role and contribution of each reserve to the network.**

I am in total agreement with these guidelines. For this reason, a systematic approach, detailing the potential benefits or lack thereof of nMPAs on managed stocks is justified, and is the intent of this paper. It is not the intent of this paper to pass judgment on the benefits of MPAs ("no take" or MPAs of other design) on any of the other stated objectives (e.g. conserving biodiversity, study sites for ecosystem research, ecotourism sites, protection of habitat from destructive fishing methods, protection of habitats from other harmful anthropogenic activities such as drilling, coastal development etc.). These are socioeconomic or scientific questions that may have socioeconomic and/or scientific consequences, but are distinct from evaluating scientifically nMPAs as a fishery management tool.

Methodology

The procedure followed here is to develop a comprehensive list of economically (commercial and recreational) important finfish from the mid to south Atlantic, the Gulf of Mexico, and Pacific US coasts (shellfish are excluded here because of the radical differences in their life history, harvest methods, etc.). For each species in the list, determine the status of the stocks (underutilized, fully utilized, over utilized, unknown). Then review their life histories, especially movement and/or migratory patterns, and make a judgment as to the possible benefits that may be conferred by establishment of an nMPA.

Determination of nMPA impacts

NMPAs are predicated on two fundamental components: keeping harvesters out and keeping the species in. The first of these is primarily an enforcement, compliance, and education issue and not to be discussed herein. The second is wholly a scientific issue, that is, whether the biology of the species is such that they will remain within an nMPA for a period of their life long enough to accrue the protection desired.

Studies assessing the management potentials of nMPAs recognize this, and the "keeping species in" component is critical in modeling efforts. For example, Nowlis and Roberts (1998) state that their models "**included the key assumptions that adults did not cross reserve boundaries and that larvae mixed thoroughly across the boundary but were retained sufficiently to produce a stock-recruitment relationship for the management area."**

In addition, for an nMPA to be an effective management tool, the clear implication is that management is needed. Thus, the stocks must be overfished, or overfishing is occurring or likely to occur, and the stocks may be approaching an overfished condition. There are formal and legal definitions for these terms, but briefly, an "overfished stock" is one whose current biomass is below that needed to maintain current harvest rates, and "overfishing" refers to a **<u>rate</u>** of fishing pressure that will lead to the overfished condition, even though current biomass of that stock is adequate to sustain maximum sustainable yield (MSY) if properly managed.

If the stocks are healthy, and projected to remain so, that is they are neither overfished nor is overfishing occurring, the need for nMPAs as a management tool is nil. This is also true if the preferred but complex ecosystem management strategy is employed, and no species within the complex is overfished or experiencing overfishing. In fact the literature is clear on this point, that if the stocks are healthy, nMPAs at best are yield neutral or will reduce harvest in some ratio to the size of the nMPAs (e.g. Polachek, 1990; DeMartini, 1993; Holland and Brazee, 1996; Sladik and Roberts, 1997; Botsford et al., 1999; Hastings and Botsford, 1999; R. Hilborn, U. of Wash. pers. com.).

Current status of fisheries

So it is first important to gain some perspective on the extent of overfishing in U.S. waters before we can assess the possible benefits of nMPAs. In the latest Report to Congress (NMFS 2001), 905 fish stocks in the EEZ were addressed, including both finfish and shellfish. Ninety-two stocks (10%) were determined to be overfished; seventy-two stocks (8%) were found to have overfishing occurring. Of these, 57 stocks (6.3%) were found to be both overfished and are experiencing overfishing. These percentages are somewhat misleading in that there were a large number of stocks for which the stock status was undetermined. However most of these were economically less important and less targeted species.

Determination of Potential Benefits

In determining possible benefits for each species, while movement patterns and stock condition are primary considerations, additional parameters include any that may impact the management of the species. Examples include utility and effectiveness of alternative management measures, presence of critical habitat, by-catch mortality, release mortality, and recruitment (i.e. larval dispersal) characteristics.

The species movement patterns of course relate to the proposed dimensions of an nMPA, but in most discussions, vast area nMPAs, covering extents within which a migratory species or all life history stages of sedentary species would be contained, are not proposed. Exceptions exist in dire cases, such as the major areas established off the upper western North Atlantic shelf, where an attempt is being made to recover the depleted ground fish stocks (NOAA, 1999). In fact, these can also be interpreted as a proxy for effort reduction on a collapsed fishery.

There have been suggestions that certain areas which serve as major migratory pathways or important spawning areas for pelagic species be considered as nMPAs (e.g. NOAA, 1999). These in fact will be discussed as critical habitat parameters, but are not what are generally considered as an nMPA, as these may be seasonal, or even variable in locale, depending on certain physical conditions.

The basic document employed for this list determination is the aforementioned “Report on the Status of US Living Resources” published by the US Dept of Commerce for the year 1999 (NOAA, 1999) and “The Report to Congress. Status of Fisheries of the United States” (NMFS, 2001). These reports provide species lists for each of the coasts, and their current stock status. This is supplemented by including additional species that may fall under individual state management, or have some economic importance external to the parameters of the federal documents. Where these species have been added, a brief commentary on the rationale to do so is included.

Thus the concern often expressed is for troubled species, and the purpose of this report is to determine if those species are potential beneficiaries of nMPAs.

Mid to south Atlantic species

Anadromous Species

NOAA (1999) lists five managed anadromous species of the Atlantic Coast: Striped bass, American shad, alewife/blueback, sturgeons, and Atlantic salmon. All these stocks are considered overfished except striped bass.

Striped bass *(Morone saxatili*s) suffered severe recruitment failures in the 1970s, but restrictive management measures implemented in the 1980s and some good recruitment levels have restored the stocks. For the other species, agricultural and industrial development and damming of rivers are cited as the major impediments to rebuilding. And while improvements of these riverine habitats may be necessary for recovery of these stocks, none of these species can be considered as potential beneficiaries of an nMPA.

Atlantic Highly Migratory Species.

NOAA (1999) lists 10 categories of highly migratory fish stocks: yellowfin tuna, bigeye tuna, albacore, skipjack tuna, bluefin tuna, “other” tunas, swordfish, blue marlin, white marlin and sailfish. Of these, all are considered over exploited, except yellowfin (fully exploited), skipjack (possibly fully exploited) and other tunas (unknown). While there is grave concern for the future of these severely overfished stocks, their highly migratory nature and requirements for international quota regulations preclude them from receiving significant benefit from an nMPA. However, identification of critical spawning areas may justify seasonal/areal closures in the future.

Atlantic Shark Fishery.

There are thirty-four species of sharks listed in the Atlantic shark fishery by NOAA (1999), however these are grouped into only three categories: large coastal, small coastal, and pelagic. The large coastal species as a group are considered overfished, although lack of knowledge of the individual species status is a concern. Small coastal sharks are thought to be fully utilized, and their stock levels above that necessary to maintain a long-term potential maximum yield. The exploitation status of the highly pelagic grouping is unknown. But practically all shark species for which tagging studies have been implemented show extensive movement patterns, and as a result, are unlikely to benefit from nMPAs. However, recent information on critical nursery areas for some species may warrant seasonal/areal closures or other measures to protect critical habitat of juveniles.

Summer Flounder.

Along the New England and mid Atlantic coast, summer flounder (*Paralichthys dentatus*) of the mid Atlantic states is a heavily exploited species, both commercially and recreationally. The species undergoes an offshore spawning migration from late summer to mid-winter, and the larvae and post-larvae drift inshore, where metamorphosis is completed, and the juveniles utilize eelgrass beds or similar habitats. The extensive migratory patterns minimize potential benefit to the species by nMPAs, however, consideration should be given to protection and even expansion of the required juvenile habitat.

Other south Atlantic and Gulf of Mexico stocks

Atlantic and Gulf of Mexico Migratory Pelagic Fisheries.

Because of their migratory patterns which ingress between both the Gulf and south Atlantic, Gulf and Atlantic migratory species are included together. The species listed include dolphinfish, king mackerel, Spanish mackerel, cobia, and cero mackerel. To this list is added wahoo, because both Management Councils (the South Atlantic Fishery Management Council [SAFMC] and the Gulf of Mexico Fishery Management Council [GOMFMC]) have recently begun an assessment and management plan for this species.

Of these seven species, only the Gulf stock king mackerel have been considered overfished, although the most recent stock assessment has concluded that this stock has now recovered to the fully utilized level (Dr. Will Patterson, chair GOMFMC Coastal Migratory Stock Assessment Panel, pers. com). Dolphinfish, cobia, cero, and wahoo fishery utilization levels are unknown. But in any case, these species are so migratory that none could be considered to benefit by an nMPA.

Atlantic and Gulf of Mexico Reef Fisheries.

About 60 species of reef fishes are managed in the South Atlantic and Gulf EEZ. For the vast majority of these, stock assessments have not been performed and life history data, including movement patterns, are also unknown. Thus any consideration of nMPA benefits for these species is pre mature. However, in recent decades, great concern has been expressed for several of the more valuable species, and more is known of their stocks and life history than the lesser known forms. These will form the analytical basis for the potential benefits of nMPAs, and for the present, can be considered as reasonable proxies for the other less studied species.

The species included in this discussion are: jewfish (= goliath grouper), Nassau grouper, gag grouper, red grouper, red snapper, vermilion snapper, mutton snapper, greater amberjack, red porgy, and gray triggerfish. Each of these is treated individually in regard to their stock status and current trends, life history parameters, and potential benefits of nMPAs.

Goliath grouper (*Epinephelus itajara*) has been a species of great concern for more than a decade. In fact, a total harvest prohibition was placed on this species in the late 1980s. Since then, the population has experienced significant recovery (A. E. Eklund, NMFS, pers.comm.), and has led many commercial and recreational fishermen to express concern that its predatory behavior may negatively impact populations of sympatric reef species, especially spiny lobsters. At the recent (January 2002) meeting of the Reef Fish Advisory Panel (RFAP) of the GOMFMC, several members noted that these stocks have rebounded so strongly and are impacting their prey species so heavily that the Panel voted unanimously to request that the Council consider a controlled harvest to determine the status of the stocks.

Nassau groupers (*Epinephelus striatus*) are found only in the most extreme southern US, primarily the Florida Keys (Sadovy and Eklund, 1999). The status of their stocks has also been of great concern, especially because of their well-documented spawning aggregations (Colin, 1992) that make them vulnerable to intense harvest at that time. For this reason, protection of these sites during spawning is certainly a positive function of an nMPA. Whether these sites should be so designated permanently would require additional studies to determine if habitat requirements were threatened by harvest activities during other times. In addition, designation of areas other than the spawning sites as nMPAs for protection of Nassau would not be beneficial, since they would leave those areas during spawning, and thus become vulnerable to capture (Bolden, 2000).

Gag grouper (*Mycteroperca microlepis*) is an extremely important commercial and recreational species, occurring along the entire mid- Atlantic and Gulf coasts. There has been a great deal of study on this species (see Turner et al., 2001) because of its economic importance, fears for the condition of the stock, the formation of spawning aggregations, its protogynous life cycle, and the possibility of a major shift in sex ratios (fewer males) due to overfishing and the extremely aggressive habits of the males during this period (Coleman et al., 1996). Several regions off the big bend area of Florida were proposed as nMPAs by the GOMFMC for this species during the spawning period (late winter-early spring), but prevented from implementation by subsequent litigation. However, the occurrence of spawning aggregations and concern over sex ratios does argue for protection in those areas well documented as spawning sites. Although the current stock assessment indicates that the stocks are not overfished (GOMFMC, Stock Assessment Panel [SAP], 2001), gag is definitely a potential candidate for protection at aggregate spawning sites and during spawning periods.

Red grouper (*Epinephelus morio*) range from Massachusetts to Brazil, and are most abundant on the west Florida and Yucatan shelves. They're found from coastal estuaries to the outer continental shelf (Robins et al., 1986; Shipp, 2000) and will likely be declared overfished during the year 2002 (Dr. Jim Cowan, chair, GOMFMC, SAP), although there continues to be a great deal of uncertainty regarding the status of the stocks, due in large part to historical catch by the Cuban fleet through the 1960s. In addition, little is known about the migratory patterns of this species. But there is no indication that they are any more sedentary than other groupers, and the juveniles occur in nearshore waters, moving offshore as they approach maturity. It is possible that adults form small breeding aggregations (Coleman et al., 1996), but whether these occur in well-defined areas is not known. If such areas are located, they could possibly be designated as an nMPA during spawning periods.

Red snapper (*Lutjanus campechanus*) has doubtlessly become the most controversial finfish species in the Gulf of Mexico, less so in the south Atlantic. It's high market value, favor by recreational fisherman, and the vulnerability of juveniles to shrimp trawls, has resulted in stakeholder conflicts on many fronts. The species was declared as severely overfished in the late 1980s and early 1990s (Goodyear, 1995; Schirripa and Legault, 1999). This resulted in numerous harvest restrictions, including minimum size limits, seasonal closures, trip limits for commercial fishermen, bag limits for recreational fishermen, and mandates for by-catch reduction devices by the shrimp fleet.

Because of these factors, and the fact that it's a reef species thought to have relatively sedentary habits, several recent papers on red snapper have cited the species as one that might be benefited by nMPAs (Bohnsack, 1996; Fogarty et al. 2000, Houde, 2001). However, on closer examination, red snapper would likely not benefit. Recent papers describing results of tagging studies (Watterson et al., 1998; Patterson et al. 2001) demonstrate that while strongly reef associated, red snappers exhibit slow movement away from tagging sites under normal conditions, and extensive movement as a result of tropical cyclones, a very frequent occurrence throughout the entire range of the species Figure 1). Thus, a "permanent" red snapper stock in an nMPA would be largely relocated to other areas with each of these events.

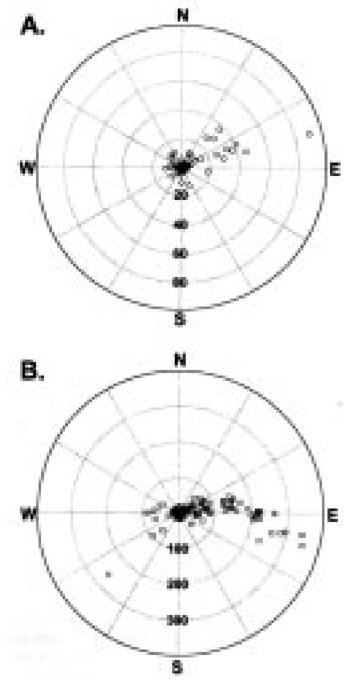

Figure 1. Polar diagrams of red snapper movement for (A) fish not at liberty during Hurricanes Opal and Georges and (B) fish at liberty during those hurricanes. Note scaler differences, in kilometers. From Patterson et al, 2001

In addition, recent model projections of snapper recovery (Goodyear, 1995; Schirripa and Legault, 1999) cite the need for very substantial (40%-80%) shrimp trawl by-catch reduction of age 0 and 1 juveniles. Red snapper larvae remain in the plankton for two weeks or more. Thus any potential contribution of larvae to the overall population from and nMPA stock would be subjected to the same mortality over most of its range. But despite the stresses experienced by the stock, red snapper appear to have begun to recover. With the implementation of the traditional management measures described above, quotas and CPUE have increased consistently during the last decade.

Vermilion snapper (*Rhomboplites aurorubens*) is a moderately important reef species of the Gulf and south Atlantic. The stock assessment panels have not been able with certainty to evaluate stock status. However, in the Gulf, it is likely that this species may be heading toward an overfished condition (J. Cowan, chair, GOMFMC Stock Assessment Panel, pers. comm.), although the most recent assessment contained so many uncertainties that the GOMFMC Reef Fish Advisory Panel in 2002 recommended "status quo" on setting a quota until a more reliable assessment could be developed. The species has been managed primarily by a minimum size limitation. There is little information as to its migratory or movement patterns, so the benefits of an nMPA for this species cannot be determined.

Mutton snapper (*Lutjanus analis*) is known to form distinct spawning aggregations. One of the best known is the Riley's hump area near the Dry Tortugas in the Florida Keys. This area is protected during the spawning season, and except for some occasional violations and attendant enforcement problems, the protection will likely benefit the species.

Greater amberjack (*Seriola dumerili*), though listed as a reef species, is better considered a coastal pelagic. Although frequenting reef areas, this active species is very mobile, and its movements, though not extensive long range migrations, do traverse hundreds of kilometers on a regular basis (Ingram, et al., in press), and thus is an unlikely candidate to benefit from any but the most expansive nMPAs.

Red porgy (*Pagrus pagrus*) ranges on both sides of the Atlantic in temperate and tropical seas. It favors live bottom habitats. It is a species of some concern regarding the health of the stocks, especially in the south Atlantic US coast. Recent increases in fishing pressure have resulted in a greatly reduced stock, and a call for reduced fishing mortality. Earlier tagging studies did not indicate extensive migrations. The species is currently under management by the SAFMC, and effort restrictions have been put in place to reduce harvest. Contingent on the results of this management and additional data on population movements, the red porgy is a species that could possibly benefit from an nMPA until stocks are returned to a level more manageable by traditional fishery methods. However, the population appears to be experiencing a substantial rebound (Dr. Robert Mahood, Exec. Dir. SAFMC, pers. com.), and a new stock assessment will be completed in June of 2002.

Gray triggerfish (*Balistes capriscus*) is a temperate-tropical species found on both sides of the Atlantic. The species has received additional fishing pressure in recent years, probably resulting from more stringent management regulations on co-occurring species, especially red snappers and groupers. However, the stocks are not considered overfished, but as a precautionary move, a 12" minimum TL size limit has been implemented by most management agencies. Recent studies (Ingram, 2001) suggest that gray triggerfish are more sedentary than previously thought, more so than red snapper, but nevertheless do display some limited movement. Should future fishing pressures indicate additional limitations on harvest, this species might be the best candidate among the fishes discussed here to benefit from an nMPA, especially given that recent stock assessment data indicate that gray triggerfish may be experiencing local overfishing in some locations in the Gulf of Mexico (J. Cowan, chair, GOMFMC Stock Assessment Panel, pers. comm.).

<u>Other Snapper/Grouper Species.</u>

In the south Atlantic, there are nine species of snappers and groupers (gag grouper, red snapper, speckled hind, snowy grouper, Warsaw grouper, golden tilefish, yellowtail snapper, red grouper, and black grouper) that are considered overfished and overfishing is occurring. The SAFMC has initiated rebuilding plans by imposing catch restrictions on all these species. These plans are generally 10-15 year plans, and most are about five years away from completion. If these traditional management measures fail, nMPAs might be appropriate for some or all of these species. However, migratory patterns of these forms are at present poorly understood. Therefore, establishment of nMPAs at this time is pre mature.

There are an additional 19 snapper/grouper species in the South Atlantic, as well as scores of sympatric species under management (e.g. grunts, porgies), for which the stock status is unknown.

<u>Southeast Drum and Croaker Fisheries.</u>

Black drum, Atlantic croaker, spot, red drum, seatrouts, and kingfishes (whitings) are included in this grouping. Atlantic croaker and red drum are considered overfished, while the other species' status is considered unknown. All these species spawn in higher salinity waters or offshore, and the young enter estuaries where they reside until reaching sexual maturity.

Of the two overfished stocks, management plans are in place for the recovery of both. Croaker (*Micropogonias undulatus*) stocks suffer greatly from by-catch discards, which include about 7.5 billion individuals killed annually (NOAA 1999). Improvement in gear designs will likely reduce this mortality and lead to recovery of the species.

A total harvest ban in federal waters by the South Atlantic and Gulf of Mexico Councils has been put in place for red drum (*Sciaenops ocellatus*). In addition, the states have implemented various restrictive harvest measures. The results suggest that these conservation measures have substantially increased the escapement of juveniles, and the offshore adult stocks are increasing.

Thus there appears no benefit of nMPAs as a management tool for the southeast drum and croaker fisheries.

Other Gulf and south Atlantic species under some form of management include striped mullet, tarpon, and snook. Only regional assessments exist for these species, but none is considered overfished on a range-wide basis, and all have moderate to long range migratory patterns, and would not benefit from traditional nMPAs. However, the juvenile phase of tarpon may benefit from some nursery area protection (Shipp, 1986).

Pacific Coast fisheries (excluding Alaska)

<u>Pacific Coast Pelagic Species.</u>

There are five species included within the Pacific pelagic group (northern anchovy, Pacific sardine, jack mackerel, chub mackerel, and Pacific herring, NOAA, 1999). All are listed as under or fully utilized, none overfished. Therefore, because of their healthy stock conditions and pelagic life history, they would receive no benefits from creation of nMPAs.

<u>Pacific Coast Groundfish Fisheries.</u>

The Pacific groundfish assemblage is a diverse group of species, principally flatfishes and rockfishes. These are mainly long-lived, slow growing species, subject to harvest by both commercial and recreational fishers. Included are about 60 species of rockfishes, principally *Sebastes* and several species of thornyheads (Genus *Sebastolobus*), several cods, the sablefish (*Anolopoma fimbria*) and the lingcod (*Ophiodon elongatus*). Recently, life history data were provided to the Pacific States Marine Fisheries Commission of the nearshore fishes of California (Cailliet, 2000). This, along with several supplementary references, and combined with the NOAA document (1999) and the Report to Congress NMFS 2001) provide the background for determination of the possible impacts of nMPAs on these species.

The Pacific whiting (=Pacific hake, *Merluccius productus*), is a mid to moderate depth species, with relatively extensive movement patterns. It is considered fully but not over exploited, and with extremely variable year class strengths. Because of these factors the species is not likely to benefit from establishment of an nMPA.

The sablefish (*Anaplopoma fimbria*) is an important commercial species, ranging from Japan and the Bering Sea to Baja. The stock status is considered fully exploited, and stock levels are below optimum. However, it is a deep water, often migratory species, thus not likely to benefit from an nMPA.

The lingcod (*Ophiodon elongatus*) is a large member of the greenling family, ranging from Kodiak Island to southern California, but is most abundant in the northern part of its range. It is an extremely important recreational and commercial species, with a high food value, although representing only about 2 % of the Pacific Coast groundfish catch. This species is considered to be over exploited, with stock levels well below that necessary to maintain the long-term projected yield. The species is relatively sedentary, usually in rocky reefs at depths of 10 to 100 m. It is a nest building species, and the males become extremely aggressive during this time, particularly vulnerable to attack by marine mammals. The species is also cannibalistic.

The life history and stock condition indicate that this species could benefit by an nMPA in the more northern part of its range. However, other management measures have been put in place, including protection of spawning and nesting sites during spawning season, minimum size requirements to ensure at least one spawn before subject to harvest, and restricted catch limits through recreational bag limits and commercial quotas. Though recovery is likely to be slow because this is a long-lived species (up to 25 years), these measures are thought to be sufficient to effect recovery (Alaska Dept. of Fish and Game, 1994).

Pacific cod (*Gadus macrocephalus)* is a wide ranging, highly migratory species of commercial importance in the North Pacific. It is considered underutilized, although stock status and long term potential yield are unknown. Therefore, the species would not benefit from establishment of an nMPA.

<u>Pacific Flatfishes.</u>

Pacific halibut (*Hippoglossus stenolepis*) is a carefully managed species, with its center of abundance in the Gulf of Alaska. Landings from the US Pacific Coast (excluding Alaska) average about 570 metric tons, representing a little more than 1% of the total harvest (NOAA, 1999). The species is well managed throughout its range by traditional methods, and recent harvest has been near record. Thus the species would not likely benefit from establishment of an nMPA.

The status of four other US Pacific Coast flatfish species (arrowtooth flounder [*Atheresthes stomias*], Dover sole [*Microstomas pacificus*] , English sole [*Pleuronectes vetulus*] , and petrale sole [*Eopsetta jordani*]) are considered individually while the many additional flatfishes are grouped together (NOAA, 1999). Of these four, none is listed as overfished, and all are wide ranging with extensive offshore movement patterns. For this reason, none would benefit from nMPAs. For the many remaining flatfish species, their stock status is unknown.

<u>Rockfishes.</u>

There are about 65 species of rockfishes endemic to the US Pacific coast, most in the genus *Sebastes*. They live in a diversity of habitats, from clean bays, to depths greater than 400 M. They are long-lived species, with some living well over 50 years. Thus, annual exploitation to attain the management goals of 35-40% spawning biomass per recruit is often as low as about 5-10%. In recent years, the surplus present in most of these stocks has been fished down, resulting in reductions in recommended annual harvest (NOAA, 1999).

In its report to Congress, NMFS (2001) lists 52 species of rockfish. For four species (Pacific ocean perch [*Sebastes alutus*], bocaccio [S. *paucispinus*], canary rockfish [*S. pinniger*], and cowcod [*S. levis*], all but the latter are major stocks) the stocks are overfished but overfishing is not presently occurring and rebuilding programs are in place or under development. These species are all wide ranging forms with extensive portions of their populations in very deep water. Thus for fishery management purposes, nMPAs are likely not needed Only nMPAs of impractical extent both longitudinally and bathymetrically would have any impact on the stocks as a whole.

For three species (darkblotched rockfish [*Sebastes crameri*], silvergrey rockfish [*S. brevispinis*], and yelloweye rockfish [*S. ruberrimus*], all major stocks) overfishing is occurring, but for the former species the stocks are not currently overfished, and for the latter two stock conditions are unknown. Reduced mortality will be required, but currently, rebuilding plans are not yet in place. These three are also very wide ranging, from the Bering Sea to southern California, and out to depths of well more than 500 M, thus nMPAs would be impractical as a management tool. And in fact, due to the bathymetry of the eastern North Pacific coast, many of the areas inhabited by rockfishes are such as to prevent extensive fishing effort, or create a "natural refuge" (see Yolklavich et al. below).

For eight species (seven of which are major stocks) for which assessments exist the stocks are not overfished, nor is overfishing occurring. For the remaining species, most of which are minor stocks, their status and rate of fishing mortality is unknown. Therefore, particular management measures are premature.

The Pacific Fishery Management Council has implemented limits for individual vessels, as well as other measures in an attempt to maintain a year round harvest for most rockfish species.

Life history data and stock assessments for most species are not yet determined. Cailliat (2000) lists data on about 30 species, and about half are known to be resident species. Of the overfished or species experiencing overfishing, movement data are available only for the canary rockfish which is considered transient/resident, with tagged movements of over 259 km documented, and the yelloweye, which is considered a resident species.

<u>General Life History Comments Regarding Rockfish.</u>

In their study of the Soquel Submarine Canyon, off Monterey California, (Yoklavich et al., 2000) suggested that "**rock outcrops of high relief interspersed with mud in deep water of narrow submarine canyons are less accessible to fishing activities and thereby can provide natural refuge for economically important fishes**." Their study was represented by 52 fish species, of which rockfishes were represented by a minimum of 24 species. In addition, they concluded that "**There was remarkable concordance between some of the guilds identified in Soquel Canyon and the results of other habitat-specific assessments of fishes along the west coast of the United States from central California to Alaska.**" Certainly this suggests that there is an inherent control of fishing effort in these habitats and consideration of more extensive areas designated as nMPAs is pre-mature and likely unnecessary.

Soh et al. (2001) studied the role of marine reserves on Alaskan rockfishes. Although Alaska is beyond the scope of this report, the findings are likely applicable. While predicting that harvest refugia (=MPA) can be used to greatly reduce discards and serial overfishing, they state that the effectiveness of marine refugia "**in fisheries management is poorly understood and concepts regarding their use are largely untested**."

Discussion

NMPAs may serve many purposes, as described above. But when intended to serve as a fishery management tool, there are several situations for which they may be extremely beneficial, and many others for which more traditional methods are much preferred. These are reviewed briefly as follows.

Benefits of nMPAs as management tools

NMPAs can have a strong beneficial impact for fishery management during periods of active spawning by aggregations, when species may be especially vulnerable to harvest, and when certain components of the stock (e.g. large male gag grouper) may be disproportionately liable to capture. This can lead to imbalanced sex ratios that can further jeopardize a stressed stock. The utility of these is likely to be seasonal, and normally would not require year around catch restrictions.

In instances where a stock is severely overfished and subject to little or no management, an nMPA can be used along with other measures to more rapidly replenish populations. This is especially true in isolated, insular populations (e.g. Roberts et al., 2001, for St Lucia) that are not strongly connected to proximal populations for replenishment.

Where habitats are damaged by fishing practices, establishment of nMPAs may help ensure habitat recovery. This is useful when these habitats, such as submerged aquatic vegetation, reef structures or other hard bottom habitat, are critical for vulnerable life stages. Oftentimes, however, gear restrictions can be enacted to lessen the social impact that would result in declaration of a total no-take zone.

NMPAs may also be beneficial where ecosystem management is employed in fisheries (primarily of near sedentary species) where by-catch of non-targeted species has become excessive, or conversely, where a protected species has reached population levels which increase natural mortality rates of targeted species, preventing a reasonable harvest (see comments on Goliath grouper, above). An nMPA will allow some version of dynamic equilibrium to return. When the equilibrium has been reestablished, then alternate, more traditional management actions may be desirable to allow yield from the system. However, ecosystem based management is still in its infancy, and much research needs to be done before tested management principles can be established.

Liabilities and “non benefits”of nMPAs as management tools

When establishment of an nMPA is intended as a near proxy for a virgin stock, several factors need to be kept in mind. And it might be helpful, in gaining perspective, to recall that some of these principles have been well known for decades or longer, though sometimes forgotten. **First, by definition, a virgin stock provides no yield.** Therefore a perfect proxy would be a negative in terms of management goals to produce an MSY or OY. However, proponents of nMPA usage for management purposes refer to a “spillover effect” of harvestable adults to adjacent areas. The impact of this spillover will always be less than that of a properly managed stock, which generates the optimal yield-per-recruit, again, by definition. These models are discussed in numerous classical and modern texts (e.g. Rounsefell, 1975; Iverson, 1996),

The issue of spillover is addressed briefly by Houde et al. (2001). The authors describe the difficulty of direct confirmation of spillover effects, and suggest models may be more useful in understanding how marine reserves function in a regional context. But they also note that those conclusions are limited by underlying assumptions on which the model is based. For species with low mobility, the spillover is minimal, yet these sedentary species are the very ones for which an nMPA is supposedly most effective.

Another claim is that larvae from an nMPA will be a significant addition to the overall stocks. This may be beneficial, but only for a very seriously depleted stock. In other cases, larval production, always in excess of the carrying capacity of the habitat, does not normally relate to year class strength. Rather density dependent factors usually control ultimate recruitment to the harvestable stock. While this principle has been the subject of scores of books and probably thousands of publications, it was espoused nearly 150 years ago by Darwin and restated frequently in most every fishery text (e.g. Gulland, 1977; Rothschild 1986).

And much more recently, data presented by the GOMFMC Coastal Pelagic Stock Assessment Panel (January 2002) re emphasizes for very practical management purposes, such as in the case of Gulf king mackerel, that egg production does not correlate to an increase in stock size, the panel stating**: “ recruitment is assumed to increase to some level of spawning stock, and then to remain at the average recruitment for higher spawning stock values (Figure 2).**”

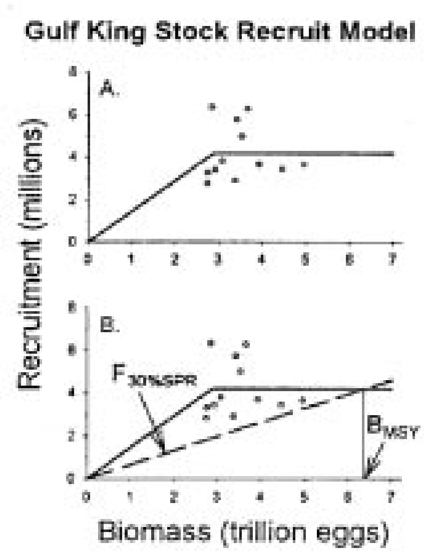

Figure 2. A) Spawner recruit model estimated for Gulf king mackerel. B) Bmsy is estimated at the intersection of the spawner recruit model and F30%SPR replacement line.

Stocks within an nMPA

There are numerous examples in the literature of stock increases within an nMPA (e.g. Johnson et al., 1999; Roberts et al., 2001). However, one must not forget what the point is here in regard to yield. While effective nMPAs may support a stock with relatively greater biomass, perhaps larger individuals, and a higher spawning potential ratio (SPR), **this portion of the stock has been removed from harvest**. Therefore, the overall yield is reduced by whatever fraction could be contributed to overall harvest from this protected stock, and mitigated only by the possibility of spillover or larval contribution, as discussed above.

Pragmatic perspective

Examination of the scores of coastal species from the mid to south Atlantic, Gulf, and US Pacific coasts reveals that very few species are known to be both overfished and/or experiencing overfishing, and are sedentary. Those candidates that are in both categories, and may possibly benefit from and nMPA, are found in widely differing geographic ranges, with optimal potential nMPA sites far apart (e.g. lingcod and surf perch in the Pacific, red porgy in the Atlantic and gray triggerfish in the Gulf). To establish an nMPA for the benefit of those few species would remove harvest potential of the scores of sympatric forms, most of which are not overfished. And while this may not reduce the overall harvest of these species, it would definitely reduce efficiency and increase fishing effort in other, adjacent areas.

Far better would be to impose more traditional methods to restore the overfished stocks, as has been done for many species. This becomes more and more successful as we adopt more precautionary harvest levels, improve our methods of stock assessment, stock/recruit relationships, and life history information.

Current plans or suggestions regarding closure of large areas of the US mainland continental shelf to harvest are simply not scientifically supportable from a fishery management perspective. The suggestion, for example, that as much as 40 % of the Southern California shelf should be designated an nMPA is totally without merit from a fishery harvest perspective. Though there may be other aesthetic benefits, such a closure would severely reduce harvest potentials, shift effort to other areas, and likely have a substantial negative economic impact on both the commercial and recreational fishing industries.

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