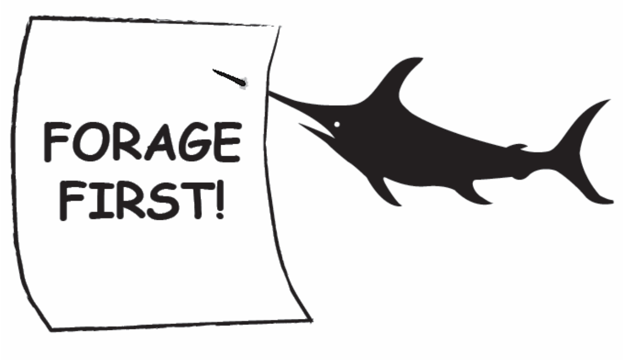
Taking the Bait

Are America's Fisheries Out-Competing Predators for their Prey?

A Report by the

National Coalition for Marine Conservation


FORAGE
FIRST!

Taking the Bait

Are America's Fisheries Out-Competing Predators for their Prey?

by Pam Lyons Gromen, Fisheries Project Director

NATIONAL COALITION

FOR

MARINE CONSERVATION

4 Royal Street, SE

Leesburg, VA 20175

TIME TO MOVE FORWARD - FORAGE FIRST

There's a Chinese saying that nature is not composed of things, but of relations. Likewise, an ecosystem is not made up of species, but of the relationships among them. Ecosystem-based management, simply put, takes those relationships into account.

In 1999, the National Marine Fisheries Service Ecosystem Principles Advisory Panel (EPAP) issued a Report to Congress, "Ecosystem-Based Fishery Management," recommending that each Regional Fishery Management Council develop and implement a Fisheries Ecosystem Plan for the ecosystem(s) under its jurisdiction. Recognizing that time, resources and changes to the Magnuson-Stevens Fishery Conservation and Management Act would be required to fully adopt a comprehensive ecosystems approach to fisheries management, the EPAP advises that "**an initial step may require only that managers consider how the harvesting of one species might impact other species in the ecosystem. Fishery management decisions made at this level of understanding can prevent significant and potentially irreversible changes in marine ecosystems caused by fishing**."

The panel's clear advice - meant to guide the regional councils in their initial goal-setting for ecosystem-based management - is to take an incremental approach, beginning with protecting key predator-prey relationships in existing fishery management plans. As a first step, it recognizes that the councils' primary responsibility is fisheries and that their authority is confined to the impacts of fishing activities on fish, associated species and their environment. In addition, the panel recommends that the precautionary approach be a fundamental policy of ecosystem-based fishery management. In the face of uncertainty, fishery managers should make risk-averse decisions that err on the side of conservation to "provide insurance against unforeseen, adverse ecosystem impacts."

In the seven years since the release of "Ecosystem-Based Fishery Management," little has been done to explicitly account for predator/prey relationships in management decisions. The hesitancy to move forward on these issues is variously explained as the result of waiting for additional science, or funding, or new legal mandates. Unfortunately, the current state of our oceans demands that we take precautionary action now.

In this report, we focus on conservation of prey fish, which are the fuel for the ocean food web. As America's fisheries, quite literally, take the bait, traditional single-species approaches are unable to tell us whether our policies are meeting the forage needs of predators, or if our fisheries are out-competing them for their prey.

The National Coalition for Marine Conservation hopes that by offering a blueprint for protecting forage species; by providing a comprehensive analysis of existing plans, focusing on what's important and what's missing; and by recommending constructive changes, we as a nation can better understand and appreciate the role these species play in the ecosystem and guard it accordingly- ***before*** we unravel the food web that supports a vital living resource for the American people.

Ken Hinman, *President*

About us…

Since 1973, the **NATIONAL COALITION FOR MARINE CONSERVATION** (NCMC) has been the only national environmental organization dedicated exclusively to conserving ocean fish and their environment. **NCMC's Mission is to build awareness of the threats to our marine fisheries and convince policy-makers at the state, national and international levels to restore and protect publicly-owned fishery resources.**

NCMC's conservation programs focus on:

- Preventing overfishing and restoring depleted fish populations to healthy levels
- Sustainable use policies that balance commercial, recreational and ecological values
- Modifying or eliminating wasteful fishing practices
- Improving our understanding of fish and their role in the marine environment, and
- Preserving coastal habitat and water quality.

NCMC served as the conservation group representative on the NMFS Ecosystems Principles Advisory Panel (1997-99) and followed up the panel's report with a workshop on Integrating Management of Predators and Prey and published the workshop's report as **"Conservation in a Fish-Eat-Fish World**."

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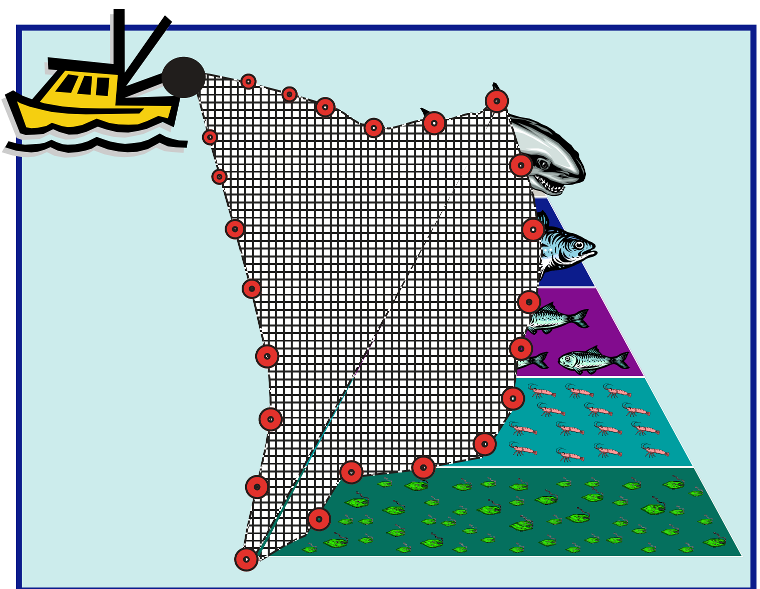
TAKING THE BAIT

- In the Chesapeake Bay, 50-70% of **striped bass** are infected with a deadly disease known to attack fish that are weakened by stress (U.S. Geological Service 2002). The Bay population of their most critical prey, **menhaden**, has dropped to low levels and decreased greatly in the diet of stripers and other predators (ASMFC 2004; Overton 2003).
- The endangered **red knot** and other migratory shorebirds that stop in Delaware Bay to dine on **horseshoe crab** eggs as they make the long trek from South American wintering grounds to breeding sites in the Arctic are not finding enough eggs to eat. As a result, many do not survive the journey (Morrison et al 2004).
- **Terns** on Machias Seal Island, an important seabird nesting site off the coast of Maine, appear unable to fill their usual diet of juvenile **herring**. Frantically racing to keep their chicks from starving, they bring moths, ants and larval fish to their nests. In 2004, not a single tern chick survived the summer (Woodwell 2005; Diamond and Delvin 2003).
- New England's fishermen are raising the alarm for another **herring** predator. The few prized **bluefin tuna** that show up on their historic Gulf of Maine feeding grounds are in poor condition, characterized by low fat-oil content and body mass (Stevens 2005).
- In the cold waters of the Pacific West Coast, the lack of primary production in 2005 left **krill** and other zooplankton scarce, triggering the collapse of the lower levels of the food chain. Emaciated **seabirds** washed ashore in record numbers. Populations of juvenile **salmon** and **rockfish** fell sharply (Chea 2005; Schwing et al 2006; Crawford and Robert 2006).
- Research on **murrelet** feathers collected from Monterey, California reveal that these threatened birds consume 42% less high quality prey than before the rise of large-scale fisheries for **sardines**, **anchovies** and **squid** (Milstein 2006; Becker and Beissinger 2006).
- Though protected under the Endangered Species Act, the **Steller sea lion** population in the North Pacific plummeted 75% over the past 25 years and only now seems to be stabilizing. Nutritional stress is a leading culprit. Before the decline, the sea lions dined on **herring** and **capelin**, but settled for pollock and cod as these fish began to dominate the ecosystem (Rosen and Trites 2000).
- **Southern resident killer whales** recently joined the Steller sea lions on the endangered species list. This population of whales that visits Puget Sound each summer was compromised by heavy aquarium collecting in the 1970s and fell another 20% in the 1990s. NOAA attributes the continued decline to "vessel traffic, toxic chemicals and limits on availability of food, especially **salmon** (2005)."
- In the Atlantic, calving rates of **right whales** are down. Scientists have discovered some whale mothers to be nutritionally unfit to carry their calves to full term (Greene et al 2003). Whale watching tours report the absence of whales from traditional feeding grounds where they formerly feasted on **herring** and **krill** (Milette et al 2005).
- Three quarters of the Pacific Coast **sardine** harvest is exported to Japan as live bait or to Australia as feed for tuna reared in offshore aquaculture pens (PFMC 2006), where operators feed 3-5 tons of sardines to grow one ton of these large carnivores.
- Three of the world's five largest fisheries are for **forage fish**, accounting for a quarter of the global fish harvest. Aquaculture consumes most of the catch and is projected to double in the next decade (Huntington et al 2004).

All these events, though seemingly remote, are tied together by a common thread, a thread that connects all sea life - the ocean food web. From fish to birds to mammals, the stories are becoming all too commonplace, while the collective plot haunts us from the depths. The ocean's creatures are going hungry.

From a young age, we learn that predator-prey relationships are the basic links in the food chain and are essential to understanding the dynamics of any ecosystem. It only makes sense, therefore, to acknowledge predator-prey interactions as the foundation on which to build goals and policies for conserving and managing fisheries in an ecosystem context.



Fishing Down the Food Web

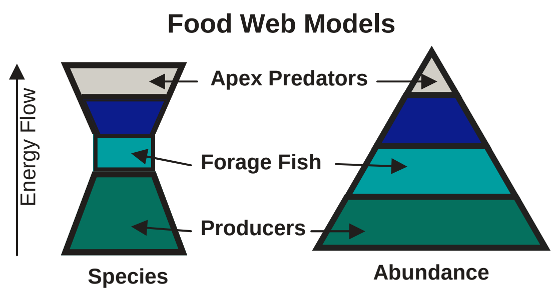
But as we focus on yields from fisheries, we short-sightedly manage the same way we fish - one species at a time. Since humans began their conquest of the seas, they have fished up and down the food web, decimating the more valuable predators like tuna, swordfish and cod, then turning to their prey. Fishery management plans (FMP) have sought to rebuild the stocks of the great ocean predators with limited success. The plans, which focus solely on populations of the target species, do little to address the big picture - the ecosystem of which these predators are an inextricable part.

Reported cases of malnourished ocean predators, added to the sluggish recovery of fish stocks (tuna, cod, billfish, rockfish, sharks), points to the need to protect prey species as the logical next step in a progression towards ecosystem-based fishery management. FMPs are in place in coastal waters for herring, squid, butterfish, mackerel, anchovy, and sardine - all crucial species that anchor the ocean food web. The National Coalition for Marine Conservation (NCMC) recently conducted a review of these plans against ecosystem management objectives and principles. This report is a compilation of NCMC's findings.

They are short-lived. For the most part, they go unnoticed beneath the surface, except for an occasional supporting role in documentaries of the majestic ocean predators. While we may not pay them much attention, the lives of many other creatures are keenly attuned to their numbers and whereabouts, inspiring migrations that cross oceans and span thousands of miles. Though small, they compensate by forming vast schools to safely navigate the seas. These immense congregations fuel the ocean food web. They are forage fish.

The term "forage fish" is used to describe species that play a significant role as prey for ocean predators, although not all species that fit this description are true fish. The most important forage species in the waters of the United States are krill, squid, and a variety of small, silvery schooling fish that include herring, sardines, anchovies, menhaden, butterfish and alewives. Collectively, these animals comprise a vital link in the marine food web because they consume plankton and other small marine organisms and transfer this energy through the food chain all the way up to top predators such as seabirds, sharks and whales.

Though their populations are large, there are relatively few individual species that perform this important ecological function. If you were to create an ocean ecosystem food web diagram that illustrated number of species at each trophic level and compared it to a diagram illustrating abundance, you would get an hourglass shape rather than a pyramid (Rice 1995). There are more species of apex predators and producers than there are of forage fish, making the abundance of each species that much more critical.



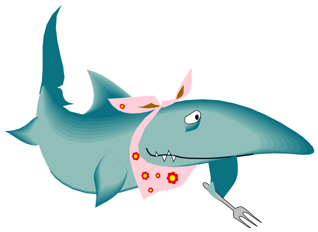
A Losing Battle for Ocean Predators

Commercial fisheries have historically targeted high-value ocean predators such as cod, rockfish, swordfish and tuna. As technology advanced, fisheries became so efficient at locating and removing their targets that stocks of these predators collapsed, and so did the fisheries. To make up for the loss of revenue, fishing operations set their sights on species lower in the food chain. Though these species were of lesser value, fishermen compensated by taking a greater number of them. Eventually, this pattern of fishing down the food web led to the large-scale harvesting of forage fish (Pauly et al 1998).

It is important to understand the vulnerability of forage fish populations when faced with modern fishing equipment. Fishing for these animals may be likened to shooting fish in a barrel. Because they swim near the surface in tight schools, they are relatively easy to locate under the surface with sonar or from above with spotter planes. Once located, they are scooped out of the water using trawls, purse seines or other forms of highly efficient nets that are capable of removing most of the school.

When fishing operations are permitted to harvest forage species when they congregate to breed, it is a double whammy for the fish stocks. Not only are a large number of them taken, they are removed from the ocean before they have an opportunity to reproduce. Spawning and other behavioral patterns are instilled in the life cycle of forage fish and are highly predictable. Experience has taught fishermen exactly how to take advantage of these patterns to maximize their catch.

Fishing during spawning periods or at other times when forage fish amass in large numbers can also be a blow to predators. Whales, tunas and sharks are just a few of the creatures that have evolved to migrate long distances to specific sites for feeding and breeding. Their survival hinges on the ability to obtain enough nourishment from their feeding grounds to sustain their long journeys. The timing and location of these feeding areas closely coincides with the behaviors of forage fish, so it is not surprising that fishermen and ocean predators are at odds competing in the same waters. Whether adapted for speed, size, endurance or stealth, the great ocean predators find themselves on the losing side of the battle when faced with the machinery of commercial fishing.



Eventually, if the ocean food web collapses, people will lose too. Commercial and recreational fishing industries provide over a million jobs and an annual infusion of billions of dollars into the U.S. economy. Our domestic seafood industry produces roughly 10 billion pounds of seafood each year, which is harvested from the ocean in every region of the country. Within the U.S., each person consumes an average of 16 pounds of seafood per year. Some U.S. seafood is exported to other countries where seafood is an even more significant food source. If the current course of fisheries and ecosystem declines is left unchecked, fish stocks may deteriorate to a point where recovery is next to impossible, destroying a vital source of protein for most of the world's population and crippling the economy with inflation and unemployment.

Choosing a New Path

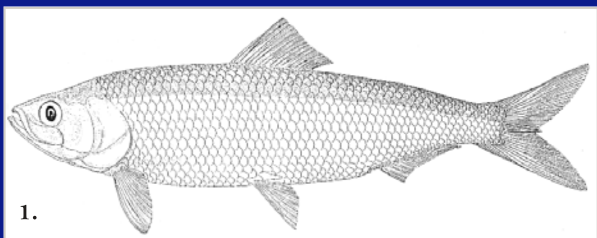
In order to fully understand the impact that commercial forage-level fisheries can have on the ocean ecosystem, we can look at the current energy crisis as an analogy for the crisis facing the ocean food web. Today, more than ever, Americans are concerned about the supply of oil. Oil is vital in order for our lives to function as we are accustomed. More of a concern than the supply of crude oil is the capacity to convert oil into its usable form, gasoline. When a handful of refineries were crippled by hurricanes in the Gulf of Mexico, there was a profound effect on the U.S. economy. Even if we were able to locate an inexhaustible source of crude oil, it would do the economy and us little good unless there were suitable refineries to provide us with the fuel we need.

The ocean food web is, in its essence, a cycle of energy. Phytoplankton - plankton that captures energy from the sun - is the raw fuel for the food web. Without forage fish to convert this energy into a form that is usable for predators, by ingesting it and becoming food themselves, the flow of energy is halted, and the food web collapses. Yet, there are few species of forage fish to perform this vital role, and large-scale commercial fisheries are in place for most of them.

In going forward, we need to ask fishery managers to broaden their strategies to make protecting the health of ocean ecosystems the guiding principle in regulating fisheries. It is imperative that we make a paradigm shift to ecosystem-based fishery management in order to establish sustainable fisheries for the long term.

Unlike ocean wildlife, we are fortunate in that we have choices. When faced with diminishing resources, we can seek substitutes to take their place. Creatures that have evolved and adapted to a way of life over millions of years have few alternatives. By choosing a new path for fisheries that safeguards the ocean ecosystem, we are making a choice for their and our own sustainability.

COMMERCIALLY IMPORTANT FORAGE SPECIES IN PACIFIC U.S. WATERS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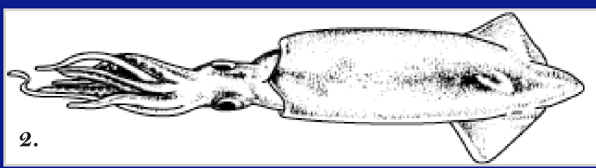
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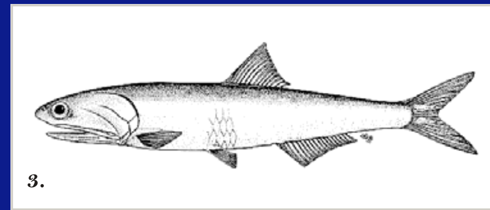
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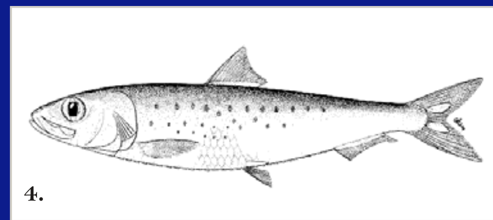
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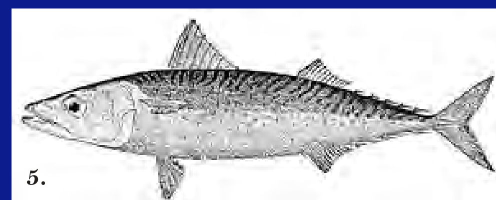
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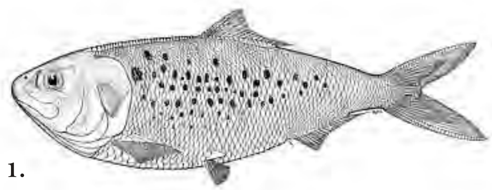
KEY FORAGE SPECIES	MAJOR PREDATORS	COMMERCIAL USES
1. Pacific Herring *Clupea pallasii*	**Fish:** Chinook and Coho Salmon, Lingcod, Pacific Cod, Halibut, Dogfish, Sablefish, Pacific Hake **Birds:** Shorebirds- Surfbird, Mew Gull **Mammals:** Fur Seal, Harbor Seal, Harbor Porpoise, Baleen Whales- Minke Whale	**Most lucrative market is for roe**; Eggs laid on kelp are an Asian delicacy called kazunoko-kombu. Other uses are: **Bait, Fish Meal, Fish Oil, Zoo and**
2. Market Squid *Loligo opalescens*	**Fish:** King and Coho Salmon, Lingcod, Rockfish **Birds:** Sooty Shearwater, Brandt's Cormorant, Rhinoceros Auklet, Common Murre **Mammals:** Harbor Seal, California Sea Lion, Sea Otter, Elephant Seal, Dolphins, Porpoises	**Human Consumption**– frozen, canned and fresh (calamari)**; Bait**
3. Northern Anchovy *Engraulis mordax*	**Fish:** California Halibut, Rockfish, Yellowtail Tuna, Shark, Chinook and Coho Salmon **Birds:** Brown Pelican, Little Tern, Black-footed Albatross **Mammals:** Fur Seal, Sea Lion, Harbor Seal, Dolphins, Porpoises, Fin Whale, Humpback Whale	**Reduction**– ground into fish meal and oil**; Bait; Chum; Human Consumption**- fresh, canned or made into paste
4. Sardine *Sardinops sagax*	**Fish:** Bonito, Tuna, Marlin, Hake, Salmon, Sharks, Mackerel, Barracuda **Birds:** Grebes and Loons, Petrels and Albatrosses, Pelicans and Cormorants, Gulls, Terns, Auks, Raptors **Mammals:** Fur Seal, Sea Lion, Harbor Porpoise, Whales	**Reduction** to fish meal and oil; **Human Consumption**– mostly canned but some fresh**; Bait**
5. Pacific Mackerel *Scomber japonicus*	**Fish:** Marlin, Sharks, Sailfish, Bluefin Tuna, White Sea Bass, Giant Sea Bass, Yellowtail **Birds:** Brown Pelican **Mammals:** California Sea Lion, Porpoises	**Reduction**– ground into fish meal and oil**; Pet Food; Human Consumption**- fresh and canned

COMMERCIALLY IMPORTANT FORAGE SPECIES IN ATLANTIC U.S. WATERS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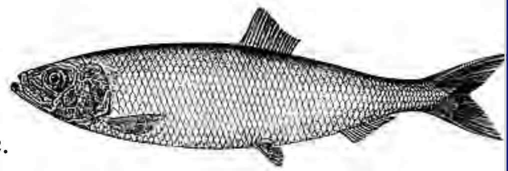
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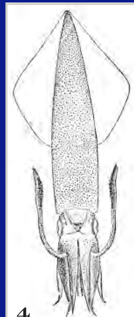
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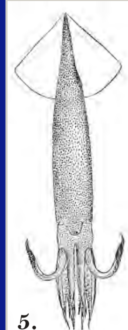
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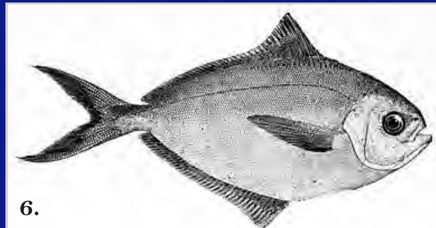
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KEY FORAGE SPECIES	MAJOR PREDATORS	COMMERCIAL USES
1. Menhaden *Brevoortia tyrannus*	**Fish:** Striped Bass, Bluefish, Sharks, Swordfish, Cod, Bonito **Birds:** Ospreys, Loons **Mammals:** Bottlenose Dolphin	**Reduction**-Fish are ground to make vitamin supplements and animal feed; **Bait**
2. Atlantic Herring *Clupea harengus*	**Fish:** Bluefin Tuna, Cod, Hake, Halibut, Flounder, Dogfish, Bluefish, Skates, Smooth Hammerhead Shark **Birds:** Northern Gannet, Shearwater **Mammals:** Finback, Humpback, Minke and Pilot Whales, Harbor Porpoise, Harbor Seal, White-sided Dolphin	**Bait; Animal Food; Seafood for Human Consumption** (flesh is canned, smoked and fresh); Eggs are harvested as roe for sushi; Scales used for cosmetics and paint
3. Atlantic Mackerel *Scomber scombrus*	**Fish:** Other Mackerel, Sharks, Tuna, Bonito, Striped Bass, Cod, Swordfish, Skates, Hake, Bluefish, Pollock, Goosefish, Weakfish **Birds:** Seabirds **Mammals:** Pilot Whale, Dolphins, Harbor Seal, Porpoises	**Human Consumption** (fresh, frozen, canned, salted)**; Bait; Zoo and Aquarium Food; Aquaculture Feed**
4. Long-finned Squid *Loligo pealei*	**Fish:** Bluefish, Sea Bass, Mackerel, Cod, Haddock, Pollock, Hake, Dogfish, Angel Shark, Goosefish, Flounder **Birds:** Diving Sea Birds **Mammals:** Pilot Whale, Dolphin	**Seafood for Human Consumption** (calamari)**; Zoo and Aquarium Food; Bait**
5. Short-finned Squid *Illex illecebrosus*	**Fish:** Bluefin Tuna, Swordfish, Hake, Bluefish, Goosefish, Flounder, Cod **Birds:** Shearwaters, Gannets, Fulmars **Mammals:** Pilot Whale, Dolphin	**Seafood for Human Consumption** (calamari)**; Zoo and Aquarium Food; Bait**
6. Butterfish *Peprilus triacanthus*	**Fish:** Swordfish, Hammerhead Sharks, Haddock,	**Zoo and Aquarium Food;**

ACCOUNTING FOR FORAGE IN FISHERY MANAGEMENT

Why Current Policies and Methods Fail Predators and their Prey

Concerns are being raised in all regions about the limited availability of forage for ocean predators. Bluefin tuna caught in New England are of poorer quality (less fat and oil content) than they were a decade ago. An alarming majority of striped bass in Chesapeake Bay are carrying *Mycobacterium*, a deadly pathogen that attacks immuno-suppressed fish. These same bass are found thin with low body fat. Frequent incidents of low shorebird nest counts and birds dying from malnutrition are reported on both the Atlantic and Pacific coasts.

Evidence of malnourished predators, contrasted with forage fish assessments that, in most cases, characterize the populations as robust or "underutilized," forces us to re-examine how we account for a healthy forage base in fishery management plans. Present practices evolve from a basic but flawed assumption. For example, the Environmental Impact Statement for the New England Herring FMP claims that current natural mortality estimates fully account for predator needs: "Implicit in the determination of the overfishing definition is consideration of the needs of other species in the ecosystem…The development of the Maximum Sustainable Yield (MSY) estimate and the target fishing mortality take into account the natural mortality from all causes, including the needs of predator species. **Because the entire management program hinges on the target fishing mortality specified in the overfishing definition, the concerns of forage species are addressed."** But a 2003 paper written by the New England Fishery Management Council (NEFMC) staff, entitled "The Role of Atlantic Herring in the Northwest Atlantic Ecosystem," acknowledges that natural mortality is difficult to quantify because the degree of predation on herring varies significantly. In a separate study entitled "Considering other consumers: fisheries, predators, and Atlantic herring in the Gulf of Maine," the authors assert that natural mortality calculations might greatly underestimate predation on forage fish. During the course of their research, they found that predation on herring by fish and mammals exceeded the level of mortality assumed by the herring stock assessment by fourfold (Read and Brownstein 2003).

When dealing with forage species, the single-species approach to traditional stock modeling fails to consider fundamental questions that must be taken into account in order to devise meaningful management measures that are effective in securing a forage base sufficient for predators. **In addition to "how much prey is available," management must also look at what, when, where and why in the framework of predation.** These variables can be overlooked in the presumption that ocean predators are omnivorous and feed on a variety of prey items; thus, it is argued, the removal of one item from the menu will not significantly impact the predator population or the food web. This thinking oversimplifies the nutritional needs of predators. Faced with hunger, a predator may dine on whatever it can find that fits into its mouth, but this does not mean that its energy requirements are met. Caloric value, digestibility and foraging effort must be considered. The deleterious effects of not considering these variables are predicted by the "junk-food hypothesis," which has been proposed as a reason for the decline of the Steller sea lion (Rosen and Trites 2000). When predators are unable to locate their preferred prey, they will substitute whatever is available including less nutritious alternatives. This can lead to nutritional stress, which can have serious effects on the health of the predator. Females experiencing nutritional stress may not have sufficient energy to reproduce successfully. Young animals needing to fulfill the high energetic demand of growth may exhibit deformities and become more vulnerable to predation themselves. In time, consuming junk-food species can lead to a decline in the quantity and quality of the predator population.

Even if an adequate number of suitable prey were set aside as a reserve for predators, this alone would have little meaning if the prey were unattainable. Abundance on a spatial basis is critical. Forage stocks targeted by commercial fisheries should be evaluated according to habitat preferences, life cycle, seasonality and distribution of populations. In a study of seabird consumption of sand lance in the North Sea, Furness and Tasker demonstrated how understanding spatial patterns of predation and geographically partitioning harvests accordingly can lead to management strategies that satisfy both the needs of the predators and the fishery (1996). Ignoring these patterns can lead to localized overfishing of prey as well as significant bycatch of predators. An example is the inshore, mid-water trawl herring fishery operating in New England. Opposition to the fishery argues that the trawl gear, in addition to taking herring from nearshore areas where tuna, whales and other predators feed, captures a significant amount of bycatch, many species of which, such as haddock, are overfished and the targets of stock rebuilding programs.

Finally, forage species management strategies must, to the best of their ability, forecast fluctuations in stocks that result from predictable changes in the environment. Forage species are highly susceptible to environmental influences. During the year of an El Niño-Southern Oscillation event, landings of market squid are up to ten times less than the yearly quota (Ish et al 2004).   Conversely, during periods of upwelling, plankton is more abundant, which has a positive bottom-up effect on forage species as primary and secondary consumers. Correlations such as this should be considered in calculations for total allowable catch (TAC), and the TAC should be adjusted to allow for a healthy forage base that is consistent with predator needs.   This sentiment is echoed by the Pacific Fishery Management Council in describing their approach to defining allowable harvest for Coastal Pelagic Species (CPS): "The original theoretical definition of MSY (maximum sustainable yield) as a constant level of catch should not be applied in the CPS fishery, because biomass and productivity of most CPS change in response to environmental variability on annual and decadal time scales."

In addition to their role as prey, forage species may serve other important ecological functions that need to be safeguarded. When oyster populations plummeted in the Chesapeake Bay, filter-feeding menhaden became even more essential consumers of phytoplankton. Without a high abundance of menhaden to filter the Bay in this capacity, the potential exists for harmful, anoxic plankton blooms to develop, causing widespread fish kills.

Variations in forage populations likely result from multiple sources: global warming, sea and wind circulation patterns, natural predation and fishing pressure. Whether fisheries are the main culprits or not is immaterial to the need for fishery management agencies to take precautionary action. If an ecosystem is compromised and productivity is down - for whatever reason - we still have to fish conservatively. The precautionary approach dictates that we take into consideration all requirements for ecosystem health ***before*** determining the parameters of fishing operations.

Moving Forward– Summary of Findings and Recommendations

Maintaining a healthy forage base and other ecosystem needs can be incorporated into existing FMPs with minor yet significant revisions. The NCMC has reviewed the following three FMPs for forage species:

- NEFMC Atlantic Herring FMP (including draft Amendment 1)
- MAFMC Atlantic Mackerel, Squid, and Butterfish FMP (Amendment 8)
- PFMC Coastal Pelagic Species FMP (Amendment 8)

These three management plans were selected because they are presently in force and because they cover key species that are targets of fishery operations and serve as critical prey for many predators in U.S. coastal waters. **Each of the selected FMPs was evaluated against a blueprint of four standards designed by the NCMC to identify and facilitate changes needed to adequately protect the ecological role of forage species.** (See Box 1 on page 12 ; a detailed analysis of each FMP's provisions follows in the accompanying tables). The results of the evaluation were encouraging, in so far as each FMP to some extent recognized the importance of the target species as prey for other wildlife. However, none of the three plans adequately addressed ***all*** areas vital to maintaining a healthy forage base in the food web.

The NCMC strongly urges the councils to revise their forage species FMPs based on the criteria outlined by the provided blueprint. (More plan-specific comments are included in the tables). With framework adjustment measures in place in each FMP, changes can begin without a lengthy amendment process. The EPAP's ambitious goal of developing FEPs to guide management will only come about through an incremental strategy. Not in one giant leap, but in carefully measured steps. We are hopeful that the following suggestions will begin that process.

Box 1

A BLUEPRINT FOR AMENDING FISHERY MANAGEMENT PLANS FOR KEY FORAGE SPECIES

The National Marine Fisheries Service's Ecosystems Principles Advisory Panel (EPAP), in its 1999 Report to Congress, encourages the Regional Fishery Management Councils to apply ecosystem principles, goals and policies to the conservation and management measures of existing Fishery Management Plans. Three actions are particularly important, the panel says. First among these - "each FMP's conservation and management measures should consider predator-prey interactions affected by fishing allowed under the FMP." (The other two actions are reducing bycatch and protecting habitat.)

1st. Explicitly feature protecting and maintaining the species' ecological role, including preservation of an adequate supply as forage for predators, as the principal plan objective.

2nd. Expand the FMP's information base to fully describe and comprehend the links among associated species, incorporating available information on ecosystem health and integrity.

3rd. Add a definition of "ecosystem overfishing" as a complement to traditional overfishing criteria, including ecologically-relevant reference points (targets and thresholds).

4th. Establish a precautionary total allowable catch (TAC) that explicitly provides a suitable buffer against ecosystem overfishing.

1. **Each FMP should be rewritten and/or realigned so that all other objectives are secondary to preserving *forage first*.** It is central to ecosystem-based strategy that protecting the ecological role of forage become ***the*** guiding principle in a forage species FMP. While no steps along these lines have been undertaken by the Mid-Atlantic Council, the Pacific and New England Councils include, or have taken action to include, preserving adequate forage among plan objectives. This objective, however, can be superseded by others in the plans, such as seeking to maximize efficiency in the fishery.

2. **Each FMP should increase and improve information on the food web in a conceptual manner so that it can be incorporated into management decisions. To be useful in an ecosystem-based management approach, predator-prey linkages should be not only identified but mapped so that critical connections can be made from the data to ecological indicators, reference points and control rules**. Fairly extensive research was compiled by each council to describe the life history of the managed species and their respective Essential Fish Habitat (EFH). Data on predator-prey interactions, quantitative information in particular, is limited. With few exceptions, it is difficult to comprehend how this information is being incorporated into management decisions. The plans note the need for additional data and continued research, but must also consider this information in terms of how it will be used in existing and newly-developed multi-species models.

3. **Each council should begin developing <u>ecological</u> reference points for each species to establish a threshold population size to serve as a proxy for allocation of the species as forage. Until these new models are developed, the councils should prevent the expansion of forage fisheries by capping harvests at current levels and imposing a moratorium on the development of new forage fisheries.** All three plans utilize MSY-based harvest strategies and, even though they are meant to guard against low abundance and achieve a stable biomass, ecosystem overfishing can occur for species that are not overexploited in the traditional sense. None of the plans attempts to define overfishing in an ecosystem context. Simply using an MSY-based definition of overfishing, calculating optimum yield (MSY as reduced by economic, social and ecological considerations), and then "not taking it all" by creating a conservative TAC is not sufficient rationale for assuring that predation needs are fully considered and accounted for in allocation to the fisheries.

> ***Not Seeing the Ecosystem for the Fish.***
>
> Another way to look at this is to consider a forest management strategy that focuses only on leaving enough trees so as not to compromise the ability of the forest to regenerate in a given time frame and continue to support a sustainable timber harvest. Trees do not exist in isolation from other elements of the forest, so such a strategy does not protect the forest's ability to support wildlife, soil conservation and watershed functions. Likewise, a standing stock of fish healthy enough to regenerate and sustain commercial harvest - even allowing that some amount of fish has been intentionally left unharvested - does not ensure that the number of fish, of the right size (age) will be left where and when it is needed in order to serve predator needs.

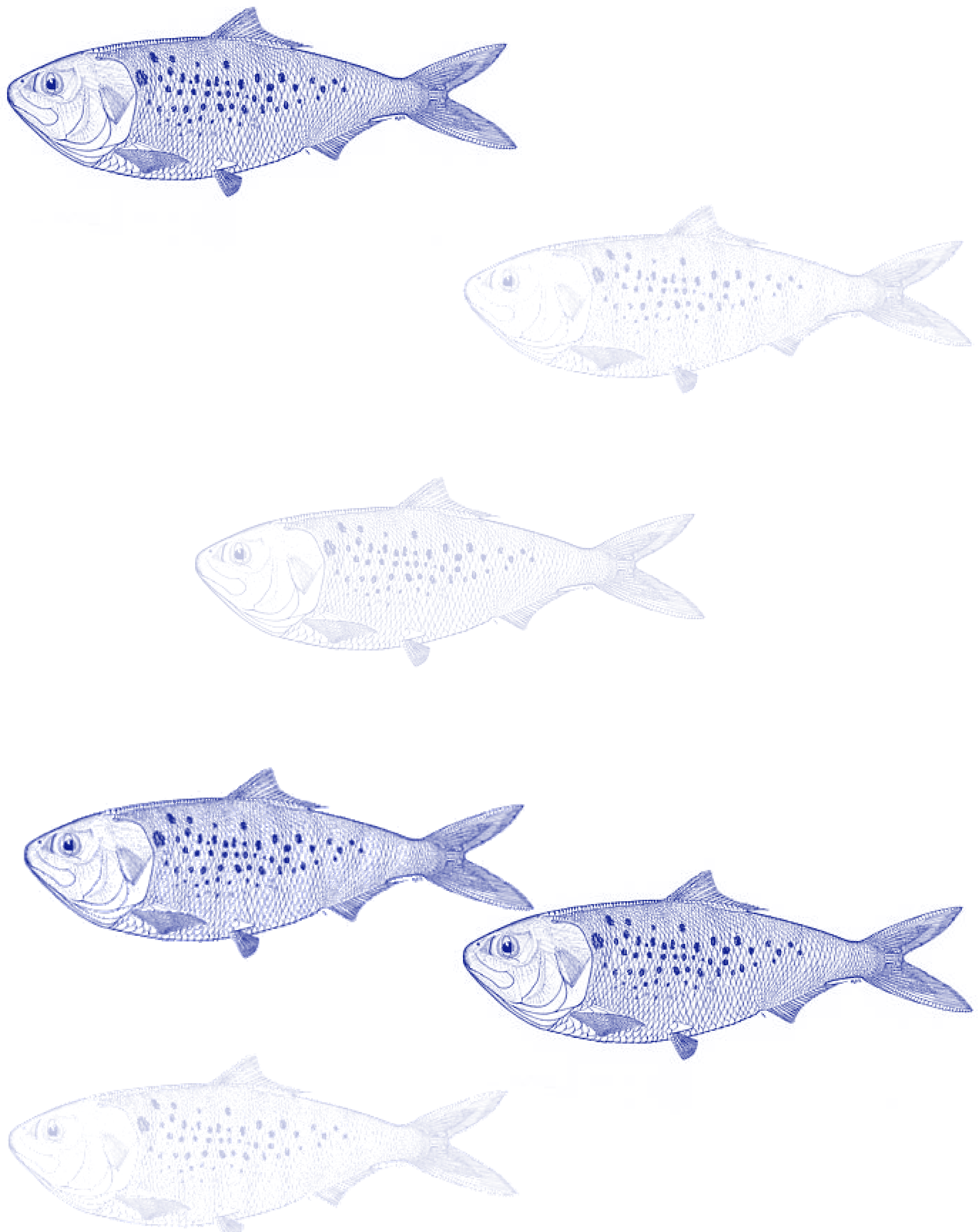
4. **Each FMP should include precautionary management measures to preserve forage that take into account quantity, density, size, age, temporal and spatial needs of predators (especially those whose populations are recovering). These measures can be implemented now and further refined as science improves.** While each plan uses biological targets and thresholds to generate buffers, only one plan incorporates measures to protect against reaching the lower threshold limits. More importantly, the lower threshold biomass designations are defined by their ability to rebuild the stocks, without any indication that these biomass thresholds are calculated to also satisfy the dynamic and substantial needs of predators. The best precautionary actions may not be simply a lump sum set-aside. In fact, time-area closures, area-specific TACs, gear restrictions, adjustments to the timing of the fishery or other management measures may better serve predators.

A BLUEPRINT FOR AMENDING FISHERY MANAGEMENT PLANS FOR KEY FORAGE SPECIES

1st Explicitly feature protecting and maintaining the species' ecological role, including preservation of an adequate supply as forage for predators, as the principal plan objective.

Elevating protection of the species' role as forage to a plan priority would require adoption of specific management measures to ensure an ecologically-balanced allocation of fish among fisheries and natural predators. There is substantial precedent for doing this. The Washington State Forage Fish Management Plan emphasizes the role of forage fish in the ecosystem and considers catch on a secondary basis: "The ability of forage fish to provide a source of food for salmon, other fish, marine birds and marine mammals will be a *primary* consideration." The recently completed NOAA Chesapeake Bay Fishery Ecosystem Plan – the first FEP developed in accordance with the EPAP's Report to Congress - recommends: "Consider explicitly strong linkages between predators and prey in allocating fishery resources. Be precautionary by determining the needs of predators *before* allocating forage species to fisheries."

FMP	PFMC Coastal Pelagic Species	NEFMC Atlantic Herring	MAFMC Atlantic Mackerel, Squid and Butterfish
OVERVIEW	**The Pacific Council was the first of the three councils to clearly recognize the importance of preserving forage for the ecosystem as a main objective for a federal FMP. With this priority set early on as a guiding principle, the Coastal Pelagic Species Plan was developed with measures designed to take into account environmental factors when deciding appropriate allocation for the fishery. The plan establishes a framework on which to build a true forage plan.**	**Inarguably, the nutritious quality of herring as food for numerous predators makes it a vital source of forage for the food web. We were encouraged that the council took action to formalize the importance of this ecological role by stating this in the revised main objectives for the FMP in the 2006 final draft of Amendment 1.**	**This plan covers a variety of important forage species yet fails to even mention their ecological role as forage and the importance of protecting this role among <u>any</u> of the FMP objectives.**
RELEVANT FINDINGS IN CURRENT PRACTICE	**Amendment 8** Within a list of 11 objectives, the Council included a goal for providing adequate forage for predators: **1.5 Goals and Objectives** Objective 6- "Provide adequate forage for dependent species."	**Current FMP** The original FMP lists 11 objectives, none of which mention the importance of herring as forage. Only objective 10 mentions consideration of ecosystem health. **2.3 Goals and Objectives** Protection of ecosystems is mentioned in objective 10: "To promote the utilization of the resource in a manner which maximizes social and economic benefits to the nation, and taking into account the protection of marine ecosystems." **Amendment 1** The original FMP goals and objectives are modified in Amendment 1. Herring is recognized for its importance as forage in objective 5, but how the Council should prioritize this importance in respect to other objectives in the plan is left vague and to the discretion of the Council.. **3.2 Amendment 1 Goals and Objectives** Preserving forage is specifically flagged as an important goal in objective 5: "Provide for long-term, efficient, and full utilization of the optimum yield from the herring fishery while minimizing discards in the fishery. Optimum yield is the amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, taking into account the protection of marine ecosystems, <u>including maintenance of a biomass that supports the ocean ecosystem, predator consumption of herring, and biologically sustaining human harvest. This includes recognition of the importance of Atlantic herring as one of the many forage species of fish, marine mammals, and birds in the Northeast Region</u>."	**Amendment 8** The plan features no objective related to preserving the species' role as forage; however, it does feature goals of promoting the growth of the commercial industry, providing flexibility and freedom to harvesters, etc., which, without an ecological objective, clearly conflict with securing a sufficient forage base for predators. **1.1.3 Management Objectives** The management objectives are: 1. Enhance the probability of successful (i.e., the historical average) recruitment to the fisheries. 2. Promote the growth of the US commercial fishery, including the fishery for export. 3. Provide the greatest degree of freedom and flexibility to all harvesters of these resources consistent with the attainment of the other objectives of this FMP. 4. Provide marine recreational fishing opportunities, recognizing the contribution of recreational fishing to the national economy. 5. Increase understanding of the conditions of the stocks and fisheries. 6. Minimize harvesting conflicts among US commercial, US recreational, and foreign fishermen.
DEFICIENCIES	Though mentioned in the list of objectives, protecting the ecological role of forage species should be the main goal and the limiting factor for fishery operations. This philosophy guided the Council's recent decision to preserve krill as critical prey for predators. But krill species alone do not comprise the forage base for predators in the Eastern Pacific. Krill share this vital role with the other species managed in the Coastal Pelagic Species (CPS) FMP. A logical next step would be to convert the CPS plan into a true forage fish management plan in the spirit of the one adopted by Washington State. A forage species FMP would prioritize preserving the forage base before determining allocation to the fisheries.	During the scoping period for Amendment 1, we urged the council to make preserving the ecological role of herring the principal plan objective. While not the main goal of the FMP, as we recommend, objective # 5 does more explicitly acknowledge the critical role herring play as forage in the ecosystem and defines optimum yield accordingly. The NCMC applauds the inclusion of this objective in the amendment, while asking the council to consider future action to make conserving herring as forage the number one plan objective.	Neither protecting ecosystem health nor preserving adequate forage is included in the objectives. The Council contends that these issues are addressed in their collaboration with NOAA's Northeast Fisheries Science Center and argues that predator/prey relationships are taken into account in fishery assessments and allocations. However, <u>how</u> this is accomplished is not explicitly described in the FMP. Without a clear objective and a transparent process for achieving it, the public has no way to understand how the Council is protecting the forage base much less hold it accountable. NCMC strongly suggests to the Council that they be more explicit in describing their ecosystem-based approaches to management, beginning with a new draft of objectives that is in line with the recommendations listed below.
SUGGESTIONS	**Ecosystem-based management dictates that needs of the ecosystem be addressed prior to the needs of the fishery. While it is intuitive that predators need adequate prey and all plans acknowledge this idea in one way or another, it is central to an ecosystem-based strategy that protecting the ecological role of forage becomes the guiding principle in a forage species FMP. Objectives of each FMP should be rewritten and/or realigned so that all other objectives become secondary to preserving forage.**		

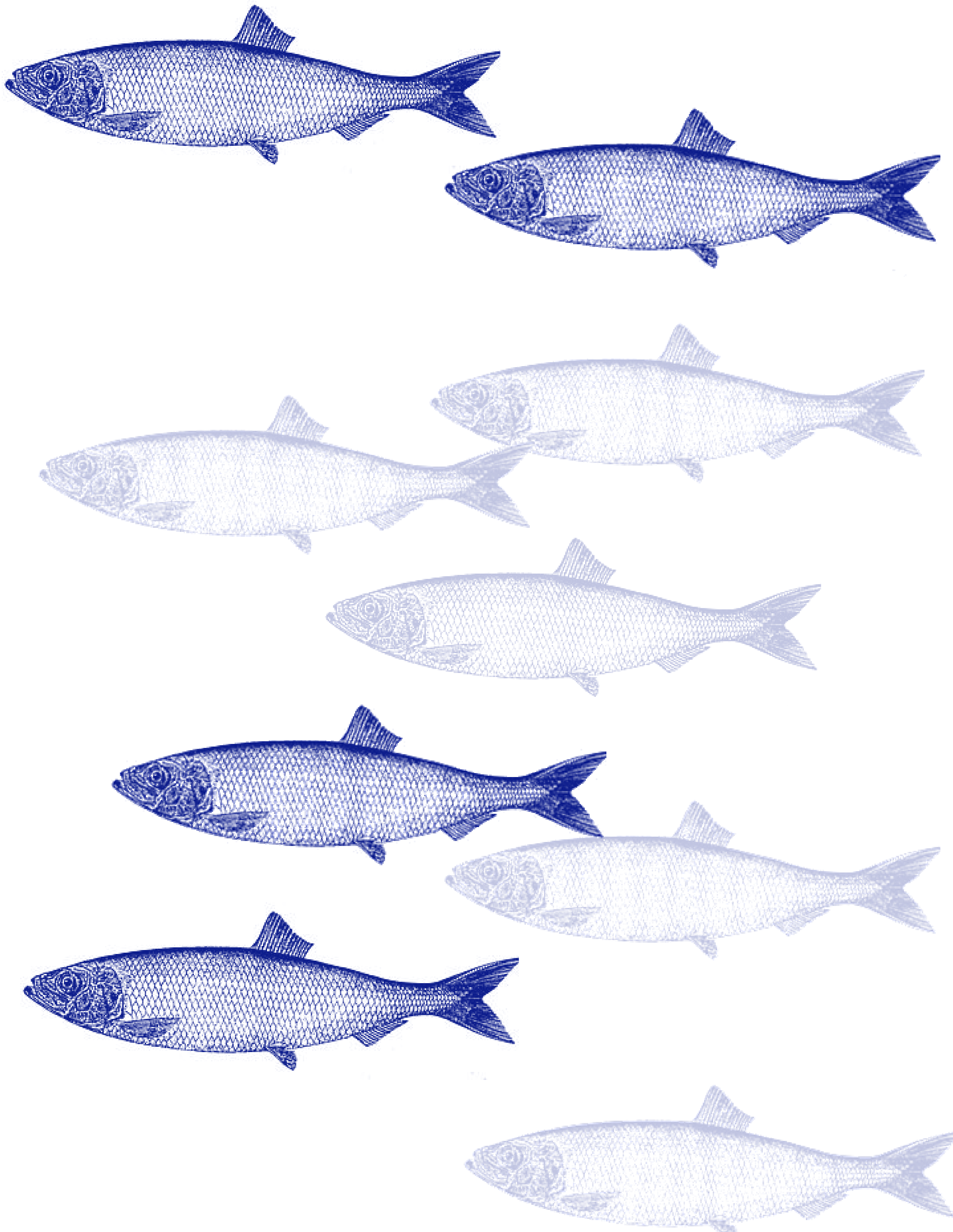


A BLUEPRINT FOR AMENDING FISHERY MANAGEMENT PLANS FOR KEY FORAGE SPECIES

2nd. Expand the FMP's information base to fully describe and comprehend the links among associated species, incorporating available information on ecosystem health and integrity.

An expanded database would provide scientists with a more comprehensive analysis for use in making an ecosystem-based assessment of the status of the population, and assist managers in making informed decisions on allocating an adequate portion of the standing stock to predators. Most FMPs contain only a superficial portrait of the species' ecological role. This information should be expanded and enhanced to describe the significant food web with quantitative and qualitative assessments of interspecies relationships, temporally and spatially, as well as at different life stages.

FMP	PFMC Coastal Pelagic Species	NEFMC Atlantic Herring	MAFMC Atlantic Mackerel, Squid and Butterfish
OVERVIEW	**Extensive data have been compiled by each council to describe the life histories of the managed species and their respective Essential Fish Habitat (EFH). Predators relying on these prey species are discussed in each plan but in varying degrees of detail. Regrettably, the plans do not make good use of this information. No specific explanations are given as to how the research is incorporated into management decisions. Though ecosystem-based research has been undertaken since the original FMPs were published, the plans do not establish a framework into which such findings can be integrated.**		
RELEVANT FINDINGS IN CURRENT PRACTICE	**Amendment 8** **Appendix A - Description of the Coastal Pelagics Fishery** Tables list known predators of the coastal pelagic species with diet preferences described for marine mammals and seabirds only. Piscivorous information is limited and only included in the abbreviated life history discussions. The life history text also provides information on spawning behavior, life cycle and diet of the managed species. **Appendix D - Description and Identification of Essential Fish Habitat for the Coastal Pelagic Species Fishery Management Plan** The importance of CPS as prey species is included in the description of EFH. EFH is a flexible definition that considers the changing habitat of pelagic species as it relates to water temperature. **Appendix B - Options and Analyses for the Coastal Pelagic Species Fishery Management Plan** **4.2.3.4** For sardines, ocean water temperature is factored into the equation for setting F_{MSY}. The objective of this control rule is to account for fluctuations in the sardine population that correspond positively with warmer ocean waters. By recognizing how environmental variables can influence abundance, allocations can be adjusted to either maximize harvest or prevent over-exploitation of the stock.	**FMP - EIS** Predators and prey are described, as well as life history, disease, migration and physical descriptions of EFH. Some important interdependencies and links between predator/prey are mentioned and quantitative information is included when available. **E.6 Affected Environment** A wealth of research and data is referenced in regard to predator/prey relationships. E.6.3.1.6 Predator/Prey Relationships Estimates suggest that 30,000-50,000 mt or ~2.5% of estimated standing stock is consumed by natural prey (fish, birds and mammals) annually on the northeast U.S. continental shelf (1990). Predation is assumed in the establishment of a constant natural mortality rate. This section does acknowledge correlations between predator and prey populations: "Fluctuations in Pacific cod and herring stocks in British Columbia between 1950 and the early 1980s suggest that herring recruitment rates were strongly influenced by cod predation. Also cod recruitment rates were positively correlated with herring abundance…" E.6.3.2 Other Stocks The FMP does caution that the herring fishery may have indirect effects (caused through ecosystem interaction) on other fish stocks and that these effects should be regularly examined. "Because herring is a key forage species, indirect effects, if not carefully monitored, may be more important than direct effects. **Omnibus EFH Amendment** This current undertaking by the Council intends to transform EFH descriptions into a form that can become a more effective management tool. The amendment is scheduled for completion in 2008. **Amendment 1 Appendices** Recent research is included in the appendices, including a paper authored by the Council entitled, "The Role of Atlantic Herring, *Clupea harengus*, in the Northwest Ecosystem," which examines the ecological role of herring as a key prey species.	**Amendment 8** Because these species are crucial to the Atlantic forage base, the addition of data that would assist in qualitatively and quantitatively identifying key predators of the managed species is as important as habitat description in moving forward. **2.0 Description of Affected Environment** Text succinctly summarizes characteristics, distribution, life cycles and habitat needs of the managed species. More useful from a management perspective are the corresponding tables and figures included in the reference section (9.0), particularly the summary tables for life history and habitat parameters for each species. These matrices provide at-a-glance detail on size and growth, geographic location, habitat, temperature, salinity, prey and predators for each major life stage of the target species. Temporal and spatial distribution information is also mapped. Absent in this section is the quantitative predator consumption data needed to distinguish major predator/prey relationships. **2.2.2 Description and Identification of Essential Fish Habitat** 2.2.2.1 Methodology for Description and Identification Mentions that EFH description is a "work in progress" and that research will be available in the near future to identify EFH more quantitatively, but because of time constraints, the Council was unable to include the data in this version of the FMP. The MSFCMA identifies four levels of data that should be used in the assessment of EFH. Data used to describe EFH for these species is characterized as Level 1 (presence/absence) or Level 2 (habitat-related densities) at best. No data at Level 3 (growth, reproduction, and survival rates within habitats) or Level 4 (production rates by habitat types) was available. The constraints imposed by lack of high-level data required the Council to identify EFH based on areas that support the highest relative abundance. Clearly, higher quality EFH data would help the Council move towards ecosystem-based management, although the Council recently concluded in a report to NOAA that it would be unable to dedicate resources to ecosystem efforts without funds from either Congress or NOAA (Mid-Atlantic Fishery Management Council, 2006). Amendments are in process for this FMP, but the EFH description may or may not be updated.
DEFICIENCIES	Aside from the sardine control rule described above, the plan does not incorporate the life history information in Appendix A in ways to assist managers in monitoring and safeguarding these species in an ecosystem context. While a step in the right direction, the sardine control rule is nevertheless based on a single-species management approach. Allocation to the fishery should not be the only consideration when forage populations fluctuate. More important from an ecosystem perspective is how other species in the food web might be affected by dramatic changes in abundance of keystone forage species such as CPS, whether due to environmental factors or fishing mortality or both. By depicting and assessing these correlations, managers can make more informed decisions, not isolated to the target species but also taking into account the impact on other managed species.	The NEFMC report entitled "The Role of Atlantic Herring, *Clupea harengus*, in the Northwest Atlantic Ecosystem," makes it clear that predation is difficult to quantify. Therefore, caution should be used when integrating hard numbers or fixed percentages into predation calculations. The data listed in E.6. give the impression that by allotting 50,000 mt or 2.5% of the stock for predation, ecosystem needs in terms of prey are met. Lump sums can be deceptive in that they do not account for the real-world interactions that comprise a successful predator/prey relationship, e.g., the prey being of the right size/age and in the right location to satisfy predator needs. The Council's own paper emphasizes, "It is not the role of herring as an individual species in the ecosystem that is most important to understand, however; the interactions of herring with its major predators and other prey species in the region should be considered critical components of successful long-term management of forage species and their associated predators." Although the report recommends that a timeline be established for incorporating predator/prey information into an ecosystem-based approach to management, no specific action toward this end was taken in Amendment 1.	Although the plan manages key forage species, the most limited background information is on predator/prey relationships. Diet composition statistics are necessary to determine significant links between predators and the forage species. For consequences listed under 2.2.3.3.1 Direct Alteration of Food Web, there are a few sentences about how removal of keystone predators affects the ecosystem. A glaring omission in this discussion is how removal of the plan's target species might impact the food web by altering the forage base.
SUGGESTIONS	**Sufficient information exists to construct topological food web and habitat use models for each region. Using the EFH description to map out the key correlations within the ecosystem with an emphasis on major predator/prey relationships would create a tool that is useful for ecosystem-based management as opposed to a lengthy text document that mainly serves to satisfy Congressional requirements. Because predator dependence on prey species is frequently linked to specific age and size classes, life cycle stages for the forage species should be included in these models. Though quantitative relationships between predator and prey ought to be incorporated when available, forage calculations for predators should acknowledge the dynamic nature of these relationships and should consider how density, size class, distribution and seasonality of forage species contributes to the ability of predators to catch their necessary share. Ultimately, the construction of multi-species models would provide valuable insight for fishery assessments and allocations.**		



A BLUEPRINT FOR AMENDING
FISHERY MANAGEMENT PLANS
FOR KEY FORAGE SPECIES

3rd. Add a definition of "ecosystem overfishing" as a complement to traditional overfishing criteria, including ecologically-relevant reference points (targets and thresholds).

Generally speaking, ecosystem overfishing occurs when reducing one component of the food web adversely impacts another, or precipitates harmful changes in the environment. This new definition would facilitate setting an Optimum Yield (OY) that properly takes into account ecological factors, as the Magnuson-Stevens Act requires, while establishing measurable criteria for achieving an optimum ecological yield. Technical guidelines for implementing an ecosystem overfishing definition should account for ecological linkages and include calculable reference points and triggers for action. After passage of the Sustainable Fisheries Act Amendments in 1996, a team of scientists was assembled to standardize criteria for the overfishing definitions required in every FMP. As the Councils move toward an ecosystem-based approach to fisheries management, including eventual development of Fishery Ecosystem Plans, it would be useful now to convene a similar panel to develop ecological reference points (benchmarks and thresholds) for defining ecosystem overfishing in FMPs.

<table>
<tr><th>FMP</th><th>PFMC
Coastal Pelagic Species</th><th>NEFMC
Atlantic Herring</th><th>MAFMC
Atlantic Mackerel, Squid and Butterfish</th></tr>
<tr><td>OVERVIEW</td><td>The FMP explicitly states that the goal is to maintain stock biomass because of the importance of these animals as forage. Including a time period associated with an exploitation rate in the overfishing definition provides some measure to protect a stock at high abundance from being depleted. This proactive stock management is a step forward from the traditional overfishing formula, which provides biological limits yet still allows for stocks to be depleted as long as they can be rebuilt in ten years. A more stable high abundance resource makes more sense from an ecological as well as economical standpoint.</td><td colspan="2">The definition for overfishing is based off the minimum standard set forth by the Sustainable Fisheries Act. While the SFA requirements to set biological limits in the overfishing definition was a leap forward for proactive fishery management (Mace, 2001), stronger safeguards need to be implemented to prevent stocks from reaching these limits. This is of particular importance in forage species plans in order to ensure that an adequate forage base is left for predators while still providing for recruitment to rebuild the stock. We recognize that the councils feel predator needs are implicitly addressed in the calculation for OY and ABC, but we believe the allocation of forage to predators (fish, mammals and seabirds) should be explicit and details should be provided as to how forage for predators is determined and taken into consideration. No specific measures were found in either plan to prevent these species from becoming "ecologically overfished."</td></tr>
<tr><td>RELEVANT FINDINGS IN CURRENT PRACTICE</td><td>Amendment 8
Though the concept of overfishing is still based off the single-species definition, control rules and proxies are used as an effort to maintain stable CPS populations and to prevent these populations from reaching the minimum thresholds.

4.3 Definition of Overfishing
Overfishing is "approached" when exploitation rates indicate that stocks will be overfished in two years. Overfishing occurs when catch exceeds ABC (Acceptable Biological Catch) determined by the control rules or is occurring when fishing mortality or exploitation rates will exceed the ABC level within two years.

Final Supplemental Environmental Impact Statement
3.3 Optimum Yield, MSY Control Rules and Overfishing Definitions
MSY control rules are described as the "most important elements of harvest management under Amendment 8." Species specific rules were adopted for actively managed Pacific sardine and Pacific mackerel. Default control rules were used for monitored species (Northern anchovy, Jack mackerel and Market squid). There is mention that research is underway to determine methods for actively managing squid if the need arises. In Amendment 10, which was implemented in 2003, MSY was defined for market squid and a control rule was incorporated to help gauge the need for active management of this species.

Appendix B- Options and Analyses for the Coastal Pelagic Species Fishery Management Plan
4.0 Optimum Yield, Maximum Sustainable Yield Control Rules, and Overfishing Definitions for the Coastal Pelagic Species.
MSY Control Rules are designed to allow for flexibility due to environmental influences on the stocks. "The original theoretical definition of MSY as a constant level of catch should not be applied in the CPS fishery, because biomass and productivity of most CPS change in response to environmental variability on annual and decadal time scales."</td><td>FMP
The overfishing definition is created and applied in a single-species context. The Council considers herring predator needs to be implicitly addressed in the MSY calculation.

2.6 Overfishing Definition
"If stock biomass is equal or greater than B_{MSY}, overfishing occurs when fishing mortality exceeds F_{MSY}. If stock biomass is below B_{MSY}, overfishing occurs when fishing mortality exceeds the level that has a 50 percent probability to rebuild stock biomass to B_{MSY} in 5 years ($F_{Threshold}$). The stock is in an overfished condition when stock biomass is below ½ B_{MSY} and overfishing occurs when fishing mortality exceeds $F_{Threshold}$."

EIS
E.7.2.1 Overfishing Definition
Mentions possibility of overfishing a specific spawning stock, Gulf of Maine. Stocks are currently all lumped together as the Atlantic coastal stock. Plans are underway to assess the Gulf of Maine stock separately to make a separate definition to reduce the likelihood of overfishing this spawning stock.

"Implicit in the determination of the overfishing definition is consideration of the needs of other species in the ecosystem…The development of the MSY estimate and the target fishing mortality take into account the natural mortality from all causes, including the needs of predator species. Because the entire management program hinges on the target fishing mortality specified in the overfishing definition, the concerns of forage species are addressed."

Amendment 1
Adjusting the management area boundaries to more accurately reflect the distribution of distinct spawning stocks is a logical progression to protect the herring resource from localized depletion. Area TACs can be monitored, calculated and set with more certainty to protect these distinct aggregations as well as manage the resource on a spatial and temporal scale to protect predator feeding grounds. <u>Distinguishing between sub-stocks for management purposes would have important implications for predators, many of which take advantage of spawning aggregations to feed.</u></td><td>Amendment 8
As with the NEFMC Herring FMP, the overfishing definitions are based on the minimum requirements of the SFA. The definitions focus on single-species rebuilding standards.

3.2 Revised Definitions of Overfishing
Overfishing is occurring when the catch associated with a threshold of F_{MSY} is exceeded. Harvest targets are set as fractions of F_{MSY} to create a buffer against overfishing.

Only in the calculations for mackerel and Loligo do threshold F and target F decrease linearly to "avoid low levels of recruitment." Still, F target does not decrease to 0 until ½B_{MSY}.

Biomass Threshold (Overfished)
Atlantic Mackerel- ¼ B_{MSY}
Loligo Squid- ½ B_{MSY}
Illex Squid- ½ B_{MSY}
Atlantic Butterfish- ½ B_{MSY}

3.4 The Amendment Relative to National Standards
MSY, B_{MSY} and F_{MSY} are used to create biological reference points for the overfishing definition.

Stock Assessments and Fishery Specification Process
The Northeast Fisheries Science Center has been researching new models to incorporate ecosystem considerations into fishery specifications. The most recent stock assessment of mackerel contains information about consumption of mackerel by its predators (Weinberg 2005).</td></tr>
<tr><td>DEFICIENCIES</td><td>While buffers, biological limits and incremental harvesting strategies attempt to take into account the ecological role of forage, it is difficult to say for certain that these measures are effective, not only for preserving the forage base but for maximizing the potential of the fishery. The forage needs of predators are not static relationships that can be factored into a simple natural mortality rate equation. Forage needs, like environmental influences, are dynamic and must be adjusted to reflect changes in the predator populations, particularly those that are targets of a rebuilding program.</td><td colspan="2">These plans do not incorporate precautionary measures to prevent forage species stocks from reaching the low end of the threshold ($<$½B_{MSY}). As new models are developed and incorporated into the fishery specification process, it would be desirable to formally detail the objectives and reference points associated with these models into the fishery management plan. Updated fishery assessment and allocation methods do not replace the need for standards that properly guide the objectives and priorities of the plan.</td></tr>
<tr><td>SUGGESTIONS</td><td colspan="3">The fundamental concept of ecosystem-based fishery management is that ecosystem monitoring informs stock assessments in determining allowable catch. "Ecosystem overfishing" can occur for species that are not overexploited in the traditional sense. In its simplest definition, ecosystem overfishing occurs when the species composition and inter-species relationships in an ecosystem are adversely modified by fishing. A more scientific definition and evaluation model for ecosystem overfishing are needed. Promising work is underway to study and define food web dynamics (Matthews Amos 2005) which will enable scientists to explicitly incorporate predator/prey relationships into stock assessments. Just as following the 1996 SFA a team of scientists was assembled to standardize criteria for overfishing definitions now required in every FMP, NMFS and the Councils should convene a scientific panel to develop ecological reference points and thresholds for defining ecosystem overfishing.</td></tr>
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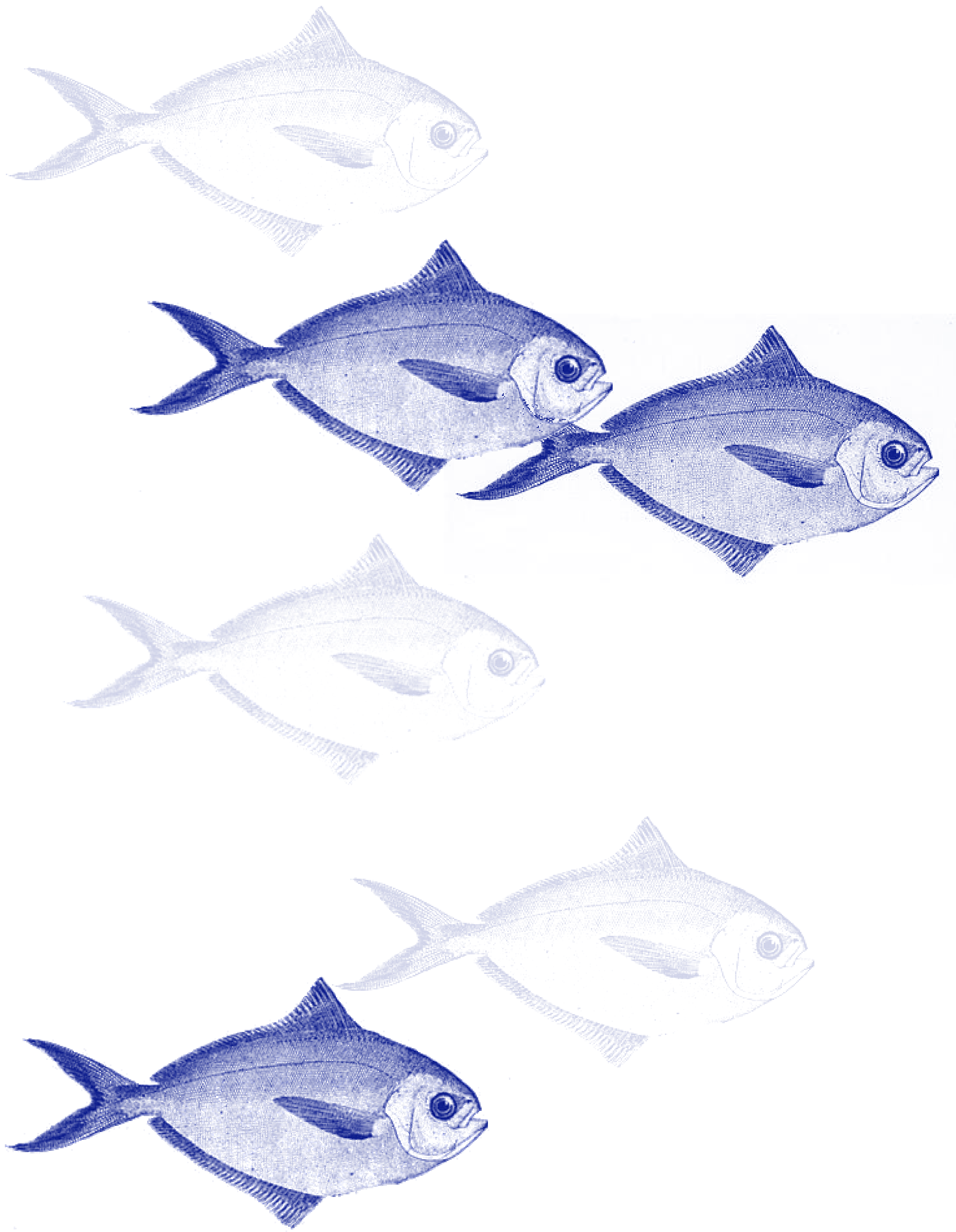
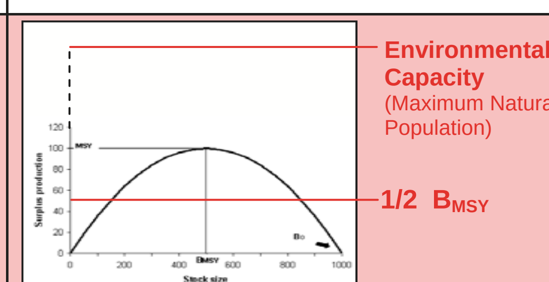
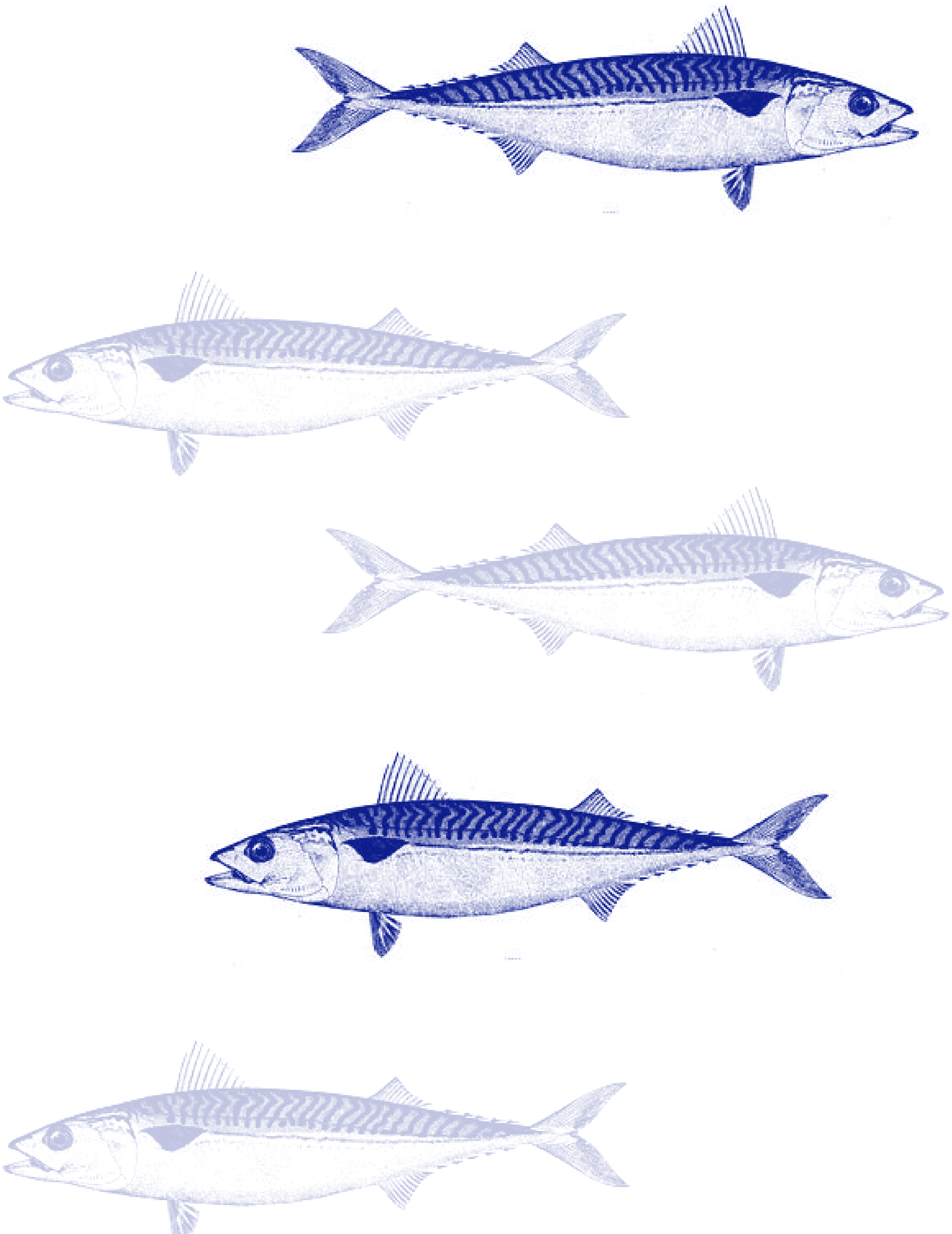


A BLUEPRINT FOR AMENDING FISHERY MANAGEMENT PLANS FOR KEY FORAGE SPECIES

4th. Establish a precautionary total allowable catch (TAC) that explicitly provides a suitable buffer against ecosystem overfishing.

Collecting, synthesizing and analyzing ecologically-relevant data and developing ecological reference points to guide management decisions takes time and will always contain a degree of uncertainty. Conservative fishing mortality targets and thresholds, as interim measures, would minimize risk to other components of the food web as our knowledge and understanding of the ecosystem improves. The NMFS EPAP advises that "(in practice, changing the burden of proof will mean that, when the effects of fishing on either the target fish population, associated species, or the ecosystem are poorly known, fishery managers should not expand existing fisheries by increasing allowable catch levels or permitting the introduction of new effort.

FMP	PFMC Coastal Pelagic Species	NEFMC Atlantic Herring	MAFMC Atlantic Mackerel, Squid and Butterfish
OVERVIEW	**The TAC is precautionary, but again, the concept of ecosystem overfishing needs to be defined in more explicit terms in order to adequately protect against it. The equation used for calculating Optimum Yield is appealing and offers a possible model for FMPs of similar species, if CUTTOFF can be further estimated to ensure an adequate forage base.**	**The original herring FMP did little to define ecological limits for the herring resource to ensure the preservation of a forage base that is vital to so many predators. Given the uncertainty of the last stock assessment, the precautionary approach to define MSY in Amendment 1 is commendable. For future calculations of OY and TAC, a reserve amount for forage should be clearly characterized.**	**Other than the biological limits for the target species, there are no limits or objectives cited with the plan itself to prevent overfishing these key forage species in an ecosystem context.**
RELEVANT FINDINGS IN CURRENT PRACTICE	**Amendment 8** Harvest is calculated based on a formula designed to continuously reduce the exploitation rate as biomass declines. The formula incorporates a fixed harvest percentage and a cutoff or threshold that is designed to provide a buffer of spawning stock to rebuild the stock should it become overfished. Though the importance of CPS species as forage is repeatedly mentioned throughout the plan, the buffer seems only to address rebuilding and does not explicitly address the needs of CPS predators. **4.0 Optimum Yield, Maximum Sustainable Yield Control Rules, and Overfishing Definitions for the Coastal Pelagic Species Fishery** Harvest is calculated on MSY control rules that are specific for managed species. The focus of the control rules is on long-term biomass rather than catch, because most of these species "are very important in the ecosystem for forage." H =(BIOMASS-CUTOFF) x FRACTION ; FRACTION≈F_{MSY} H is the harvest target level, CUTOFF is the lowest level of estimated biomass at which directed harvest is allowed and FRACTION is the fraction of the biomass above CUTOFF that can be taken by the fishery. Maximum harvest levels (MAXCAT) are incorporated to guard against extremely high catch levels due to errors in estimating biomass, to reduce annual fluctuations in catch levels and to avoid overcapitalization during short periods of high biomass and high harvest. This measure also prevents catch from exceeding MSY at high stock levels and spreads the catch from strong year classes over more fishing seasons. **2.1.2 Point-of-Concern Framework** 2. Any adverse or significant change in the biological characteristics of a species (age composition, size composition, age at maturity, or recruitment) is discovered. 4. Any adverse or significant change in the availability of CPS forage for dependent species or in the status of a dependent species is discovered.	**FMP** Buffers are factored into the calculations for the overfishing definition and for the Allowable Biological Catch (ABC). However, these buffers are based more on uncertainty in biomass calculations and projections than they are based on calculated needs for herring predators and the herring stock itself. The precautionary tactic seems only to apply to a "fishing up" period, giving the impression that the Council will be less conservative as the fishery grows and becomes established. **2.6 Overfishing Definition** "Because of the key role of herring in the ecosystem and uncertainty over stock structure, the Council established $B_{Threshold\ as}$ ½ B_{MSY}" **3.2 Specifications** Although current biomass was estimated much higher than B_{MSY} and could have resulted in a larger harvest applying F_{Target} to the biomass, the council applied the following control "Because estimates of current biomass are very uncertain, the wide fluctuations in stock size often experienced by pelagic resources, uncertainty in the estimate of MSY and the key role of herring in the ecosystem, ABC will be limited to F_{MSY} times B_{MSY} during an initial "fishing up" period." **3.3.5 Framework Adjustment Measures** Allow changes to be made in regulations in a timely manner without an amendment process **3.3.6 Management Measures That Can Be Adjusted Through Framework** Examples: 3.3.6.3 Closed Areas Other than a Spawning Closure- to provide an adequate forage base for other spawning fish at specific times. 3.3.6.17 Changes to Overfishing Definitions- allows for flexibility to incorporate more appropriate biological reference points as new evidence is uncovered. **Amendment 1** The amendment establishes a precautionary proxy for MSY that is more conservative than the previously used figure. The Council expressly cites the reason for their decision is the concern for herring predators in the managed areas.	**Amendment 8** The Council uses the fishery specification process to consider and provide for the needs of predators and therefore, considers these needs to be implicitly addressed within the annual allocations. Minimum biomass thresholds are based solely on the single-species rebuilding requirements in National Standard 1 of the SFA. A conservative or precautionary approach in setting minimum biomass thresholds is only used in species for which there is uncertainty in the stock assessment. **3.2 Revised Definitions of Overfishing** The minimum biomass threshold is set at ½ B_{MSY} for both species of squid and for butterfish. Minimum stock biomass for mackerel is ¼ B_{MSY}. Maximum OY is set at the catch associated with F_{MSY}. **3.1.1 Framework Adjustment Process** Allows the Council to add or modify management measures through a streamlined public review process. This includes the overfishing definition.
DEFICIENCIES	The harvest equation would be more effective at protecting the ecological role of forage species if CUTOFF was based not only on the stock's ability to rebuild, but in addition, incorporated a reasonable estimate as a reserve for forage that is based on key predator/prey correlations. When data are unavailable, a precautionary reserve should be factored into the level of uncertainty.		The logic behind establishing a threshold of 1/2 B_{MSY} or less as an adequate reserve of forage is unclear, especially considering that 1/2 B_{MSY} typically falls at 1/4 of the population at its environmental capacity. This seemingly arbitrary threshold would have to provide adequate forage for predators as well as leave enough adult stock to repopulate to MSY according to the rebuilding plans. Sufficient information is not presented to argue that this threshold is sound to serve both functions. A reserve number set aside for forage separate from the rebuilding breeding stock might satisfy this criterion. This number would need to be carefully configured on a regular basis to allow for fluctuating needs of predators and other natural influences on the abundance of forage species. When faced with uncertainty, the reserve allowance should factor in a precautionary number.
SUGGESTIONS	**All councils have framework adjustment measures in place that would enable revisions to the overfishing definition without a lengthy amendment process. With this mechanism in place, changes can be made to adopt more explicit ecosystem-based management strategies as outlined by the NCMC blueprint. While work is needed to characterize ecosystem overfishing in measurable terms, precautionary measures in the form of delineating and putting aside a reserve of forage that takes into account quantity, density, size, temporal and spatial needs of predators (especially those whose populations are recovering) can begin to be implemented with current information and developed more fully as new science is available. <u>Since the majority of the forage species fisheries are classified as underutilized, these reserves should not have a significant impact on current fishery operations. The goal is to understand these limits now so that the fisheries do not grow beyond their ecological limits.</u>**		



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NATIONAL COALITION FOR MARINE CONSERVATION

4 Royal Street, SE

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(703) 777-0037

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