RETHINKING SUSTAINABILITY:
A NEW PARADIGM FOR FISHERIES MANAGEMENT

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EXECUTIVE SUMMARY

"The assumption that the current single-species management approach [to fishery management] is ecologically safe is highly questionable and must be challenged."[1]

Our oceans are in crisis, a fact that has been all too well established by scientists, but not yet addressed by policy makers. While climate change, toxic pollution, destruction of coastal habitats, and high nutrient runoff are collectively wreaking incalculable havoc on marine ecosystems, it is the industrialization of fishing that has been responsible for the most sweeping changes. Worldwide populations of large predatory fish, including marlin, swordfish, and tuna, have been reduced by 90% since the introduction of industrial fishing.[2] The deep-sea coral and sponge forests of the continental shelves have been decimated by bottom trawling. Entire fishing communities have ceased to exist, while at the same time, the fish populations on which they once depended have collapsed.

Photos Top (L to R): Alaska pollock © 2006 Alaska Stock; Steller sea lions, S.E. Alaska © 1989 John Hyde/Greenpeace; Alaskan fishing boats © Greenpeace.

Fortunately, the rapid decline in the diversity and abundance of marine life is not irrevocable if we muster the social and political will to act decisively. Successive ocean commissions have called for meaningful and immediate change in the way we manage our oceans and their valuable resources. In February 2006, Admiral James Watkins and the Honorable Leon Panetta, chairmen of two expert commissions on oceans, issued our nation's administration, governors, and legislature a "D+" for ocean policy in their U.S. Ocean Policy Report Card. The Joint Ocean Commission Initiative, made up of chairmen and commissioners from both the U.S. Commission on Ocean Policy and the Pew Oceans Commission, is aiming at "accelerat[ing] the pace of change resulting in meaningful ocean policy reform."[3] One of its most important findings is the urgent need for a shift to ecosystem-based management (EBM). A key component of this crucial reform in ocean governance and policy is the establishment of a network of fully protected marine reserves.

> **"We have reached a crossroads where the cumulative effect of what we take from, and put into, the ocean substantially reduces the ability of marine ecosystems to produce the economic and ecological goods and services that we desire and need. What we once considered inexhaustible and resilient is, in fact, finite and fragile."**
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> Pew Oceans Commission, *America's Living Oceans: Charting a Course for Sea Change. A Report to the Nation* (Arlington, VA: Pew Oceans Commission, 2003), v.

The scientific community, the federal fisheries agency, Congress, and the Bush administration have all spoken of the necessity to move to a more comprehensive approach to fisheries and oceans management. While this recognition is crucial, it has not yet been backed up by action. As a result, our marine ecosystems continue to suffer.

> *"We do not know the full effects of commercial fishing on the environment, nor do we understand the effects of fishing on the ecosystem and its processes."*[4]

This statement, made by National Marine Fisheries Service (NMFS), the federal agency responsible for managing our nation's fisheries, reflects the lack of understanding of marine ecosystems and fishing's impacts upon them. Rather than employing the precautionary principle and placing the burden of proof on the fishing industry, our current system is set up so that irreversible harm must be demonstrated before the unsustainable extraction of marine resources and/or destruction of habitat is stopped or reduced.

For the first time in ten years, Congress is preparing to reauthorize the Magnuson-Stevens Fishery Management and Conservation Act (Magnuson-Stevens Act, or MSA), the law that governs federal fisheries, and consider what changes in the national law are needed for the future. Reauthorization comes on the heels of clarion calls for major reforms of fisheries management, national ocean policy, and governance in recent national panel reports, all of which have called for adoption of a more holistic, ecosystem-based approach to fisheries management.

The message is clear: we need to rethink the myopic, single-species approach to fishery sustainability in the MSA; protection of marine ecosystems on which the fish depend should be the organizing principle of fisheries management and ocean policy.

FACTORY FISHING ON THE LAST FRONTIER

"It is difficult to fully appreciate the extent of the changes to ecosystems that fishing has wrought . . ."[5]

The limits of sustainability as defined in the Magnuson-Stevens Act are illustrated by the Alaska pollock fishery, the nation's largest fishery, as well as the largest food fishery in the world. However, the fishery-focused definition of "conservation and management" in federal fisheries law fails to account for the impacts of the fisheries on marine food webs and habitats in an ecosystem context. The Alaska pollock fishery typifies these shortcomings.

The U.S. territorial seas off Alaska's 33,000-mile coastline are twice the size of the combined East and West Coast exclusive economic zones (EEZ[6]) and include some of the most productive marine ecosystems in the world. Historically, these ecosystems have supported some of the largest assemblages of marine mammals and seabirds on Earth, and – since the 1960s – an enormous fishery for bottom-tending "groundfish," primarily Alaska pollock. The biggest source of this bounty is the extensive continental shelf in the eastern Bering Sea, accounting for about half of the marine fish and shellfish caught in the entire United States annually.

Photo: Factory trawler *Northern Eagle* fishing for pollock in the Bering Sea © Greenpeace/Visser.

FIGURE ES-1. MAP OF BERING SEA/ALEUTIAN ISLANDS AND GULF OF ALASKA

SOURCE: NMFS, *Alaska Groundfish Fisheries Final Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2004).

IMPROVING UPON THE ALASKA APPROACH TO OVERFISHING

Sustainability is the watchword of the reauthorized Magnuson-Stevens Act, also known as the Sustainable Fisheries Act of 1996. Yet the word "sustainable" appears in the statute only in reference to "maximum sustainable yield" (MSY), which is the statutory yardstick by which successful conservation and management are measured. The MSA is focused on maximizing resource utilization, and sustainability is defined in terms of economic benefits of and for fisheries, not stewardship of natural ecosystems or ecological integrity.[7]

The Alaska approach to overfishing employs a system of enforceable catch limits, or quotas, based on criteria for achieving MSY from individual species or groups of species in each fishery management plan (FMP). In the current debate over MSA reauthorization, advocates of enforceable catch limits as a method to prevent overfishing in U.S. fisheries have portrayed the Alaska fisheries as models to emulate.

OVERFISHING: MSY AS YARDSTICK

In the 1996 amendments to the Magnuson-Stevens Act, the terms "overfishing" and "overfished" are defined as a rate or level, respectively, of fishing mortality that jeopardizes the ability of an exploited fish stock (or group of species treated as a "stock" for management purposes) to produce the maximum sustainable yield (MSY) on a continuing basis.

In the simplest terms, MSY is the largest catch that the stock can sustain, on average, over a long period of time, given current ecological and environmental conditions. This sounds like a straightforward concept, but the Magnuson-Stevens Act's own national standard guidelines on overfishing cautioned that MSY is a *theoretical* concept rather than an empirical one.

That cautionary note has been all but lost in the debate about enforceable catch limits and Alaska's approach to overfishing. Measuring fishery sustainability by the theoretical yardstick of MSY is fraught with uncertainty, and the approach ignores the ecosystem.

Catch limits establish a bright line, defining the scope of opportunity as well as the limits of the resource. But catch limits by themselves are not a panacea; following scientific advice on fishing mortality limits is just the beginning. Once managers set a catch limit, they must be able to enforce it, which means they also need reliable measures of catch, including incidental bycatch of non-target species. Effective quota-based management is information-intensive and expensive.

The use of fishing mortality control rules and catch limits does not guarantee that overfishing will not occur, in part because the true abundance of fish in the ocean is inherently uncertain. Indeed, the highly theoretical yardstick of MSY and overly simplistic assumptions of "state-of-the-art" stock assessments are fertile ground for mistakes. The collapse of the northern cod fishery of Canada serves as a reminder of the fallibility of claims of conservative single-species quota management. Errors in stock size estimation were most likely responsible for the rapid collapse of Alaska's red king crab fishery in the late 1970s and early 1980s, which was the most lucrative fishery in the Bering Sea at the time.[8]

Photo: Factory trawler *Ocean Rover,* Bering Sea, Alaska © Visser/Greenpeace.

UNCERTAINTY IN CATCH LIMITS NECESSITATES GREATER PRECAUTION

Single-species stock assessment models oversimplify population dynamics of wild, free-ranging fish and tell us nothing about the larger uncertainties associated with

- **climate variability;**
- **food web dynamics in the ecosystem;**
- **the impacts of fishing gear on the habitats of fish and other wildlife;**
- **the spatial and temporal effects of concentrated fishing in localized areas; or**
- **the effects on hundreds of poorly understood non-target species taken as bycatch.**

Thus, much of the uncertainty and risk inherent in managing large fisheries is left out of the stock assessment calculation of acceptable biological catch (ABC).

For all these reasons, stock assessments and catch limits by themselves are no guarantee of avoiding overfishing or fostering recovery:

> ***. . . many stock assessments have been predicated on the assumption that survey estimates of abundance, age-specific metrics of commercial catch, and a broad sense of the geographical limits of a commercially harvested fish population are all that one really requires to understand and predict the effects of fishing on fish populations. Yet, for many fisheries, we seem unable to predict either the susceptibility of fish stocks to collapse or their ability to recover therefrom.***[9]

The failure of single species or stocks of fish to respond predictably to MSY-based exploitation strategies may be attributable to inadequate information, flawed assumptions about species responses to a regimen of fishing mortality, extrinsic factors such as climate variability, or all of the above. Uncertainties and risks must be fully recognized and accounted for in setting catch limits. A great deal more precaution must be exercised in setting catch limits, and in cases of uncertainty, managers should err on the side of protecting the ecosystem.

POLLOCK'S CENTRAL ROLE IN THE NORTH PACIFIC FOOD WEB

> *It seems extremely unlikely that the productivity of the Bering Sea ecosystem can sustain current rates of human exploitation as well as the large populations of all marine mammal and bird species that existed before human exploitation — especially modern exploitation — began.*[10]

A common thread linking marine predators in western Alaska is their reliance on walleye pollock *(Theragra chalcogramma)*, a prolific member of the cod family whose range extends across the North Pacific Rim from Puget Sound to the Sea of Japan. Pollock's central importance as a forage fish in the Bering Sea food web has been known since the 19th century, hence pollock's scientific name, *Theragra*, from the Greek *Ther* (beast) and *agra* (prey or food).[11] Pollock is widely consumed at every stage of its life cycle by mammals, birds, invertebrates, and fishes.

Pollock is the dominant prey fish in the eastern Bering Sea,[12,13,14] and was the dominant prey of groundfish and Steller sea lions in the Gulf of Alaska during the 1990s.[15,16] Groundfish predators of pollock include some of the most abundant and highly valued species in the Bering Sea and Gulf of Alaska.[17]

The explosive growth of the pollock fishery since the 1960s has been accompanied by steep declines of top predators in the pollock food web, including endangered Steller sea lions, depleted northern fur seals, depleted Pacific harbor seals, and some seabird species, indicating major changes in the structure of the ecosystem.[18] The threats posed by this fishery to pollock consumers in the ecosystem have been a lightning rod for controversy and conflict in scientific, political, and legal arenas for nearly two decades.

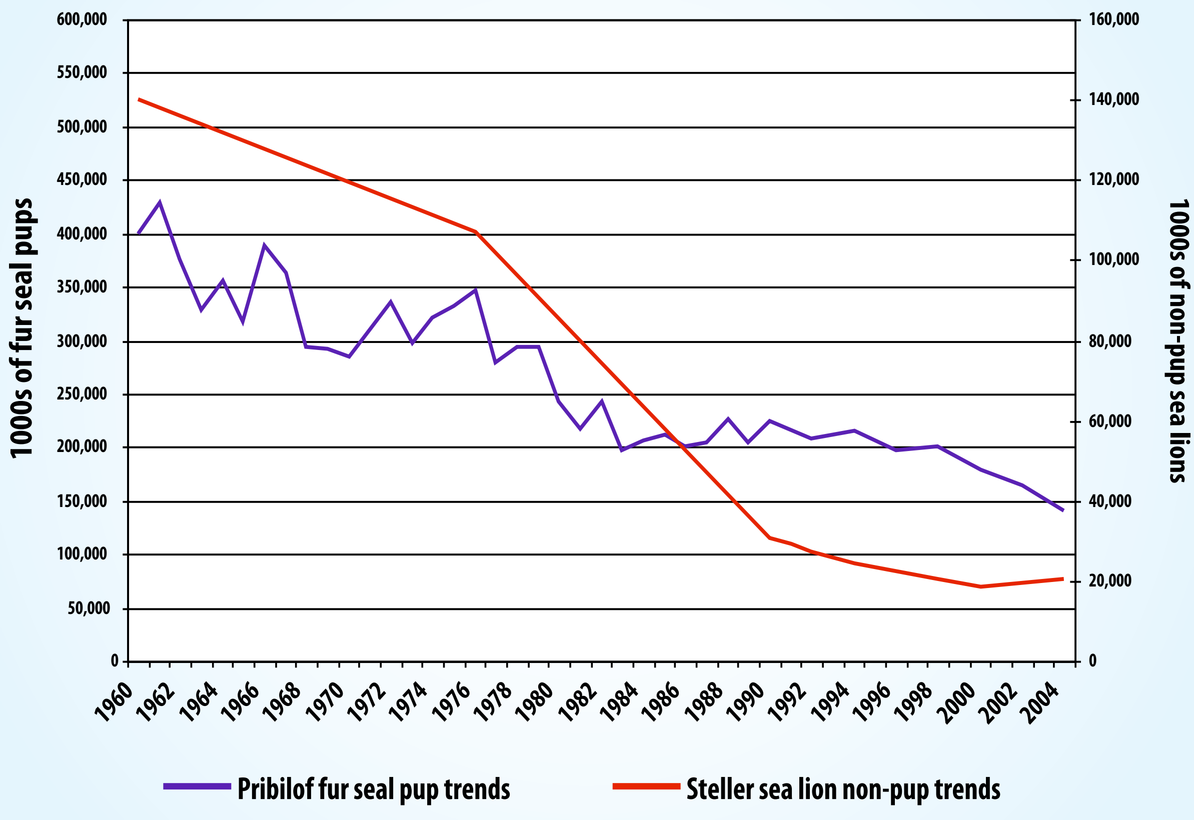
Photos (L to R): Humpback whale with calves; Steller sea lions, Round Island, Bristol Bay, Alaska; Red-legged kittiwakes on rock ledge, St. George Island, Alaska. All © 2006 Alaska Stock.

OVERFISHING IN AN ECOSYSTEM CONTEXT

The simplest way to describe Alaska's approach to overfishing is this: remove 60% of the fish out of the stock population by fishing, and the remaining 40% will produce the maximum sustainable yield. Any new production in the "target" stock above the 40% level is considered a surplus for the fishery.[19] As the 1999 Bering Sea/Aleutian Islands (BS/AI) Fishery Management Plan acknowledges, however, there *is* no surplus production in marine ecosystems for fisheries to take.[20,21] In the absence of the enormous pollock fishery, the foregone catch would be turned not into fake crabmeat or fish sticks, but into more fur seals, sea lions, seabirds, whales, halibut, cod, and pollock.

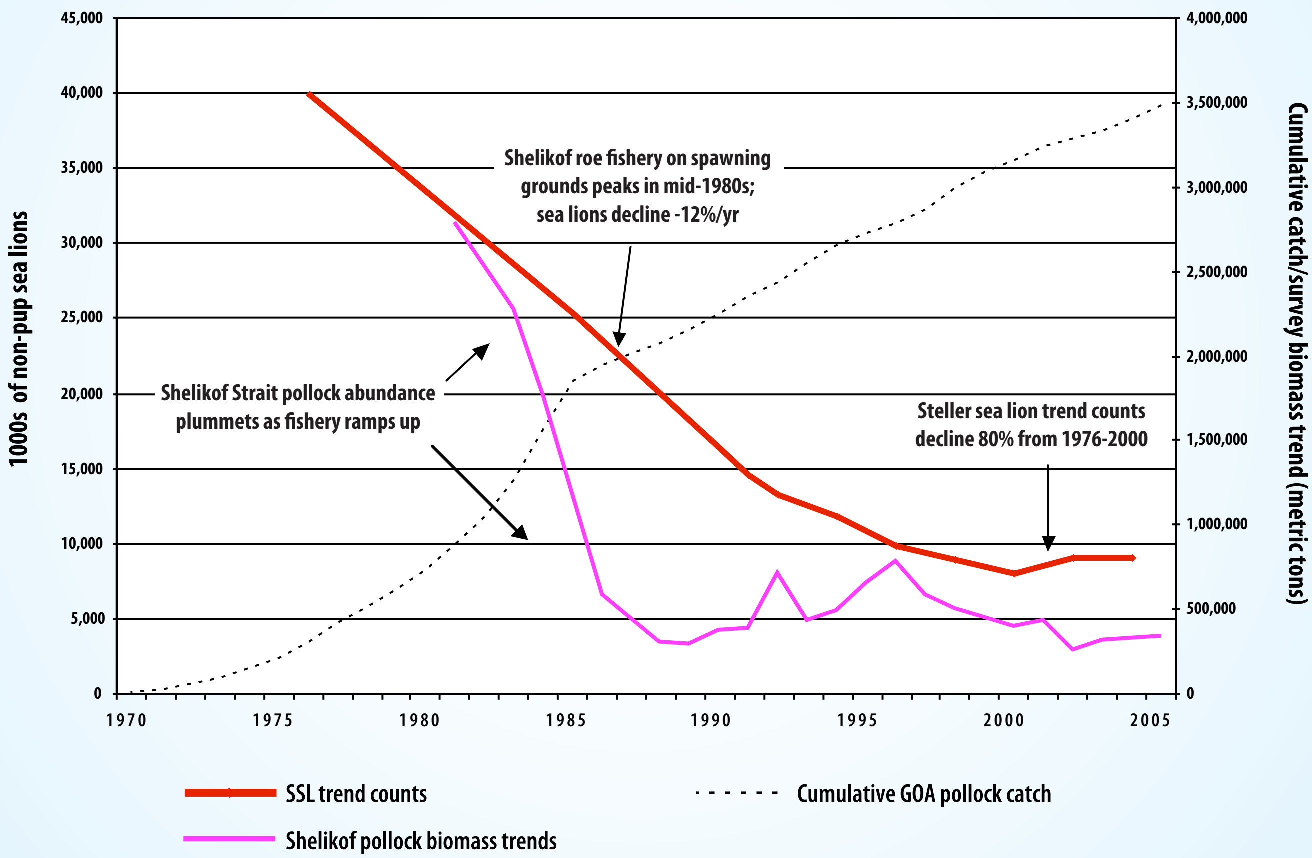
> **"The North Pacific marine ecosystem appears to be suffering from a serious case of single-species management, compounded by a narrow regimen of extraction-based policymaking."**
>
> Alaska Oceans Program, *Vital Signs in the North Pacific: Code Blue for the Ocean* (2005).

FIGURE ES-2. TRENDS IN NORTHERN FUR SEAL PUPS ON THE PRIBILOF ISLANDS AND STELLER SEA LIONS IN WESTERN ALASKA, 1960–2004



SOURCE: National Marine Mammal Laboratory (NMML), (Seattle: Unpublished data).

FIGURE ES-3. CUMULATIVE GULF OF ALASKA POLLOCK CATCH (1970–2004), SHELIKOF POLLOCK BIOMASS TRENDS (1981–2004), AND REGIONAL STELLER SEA LION TREND COUNTS (1976–2004)



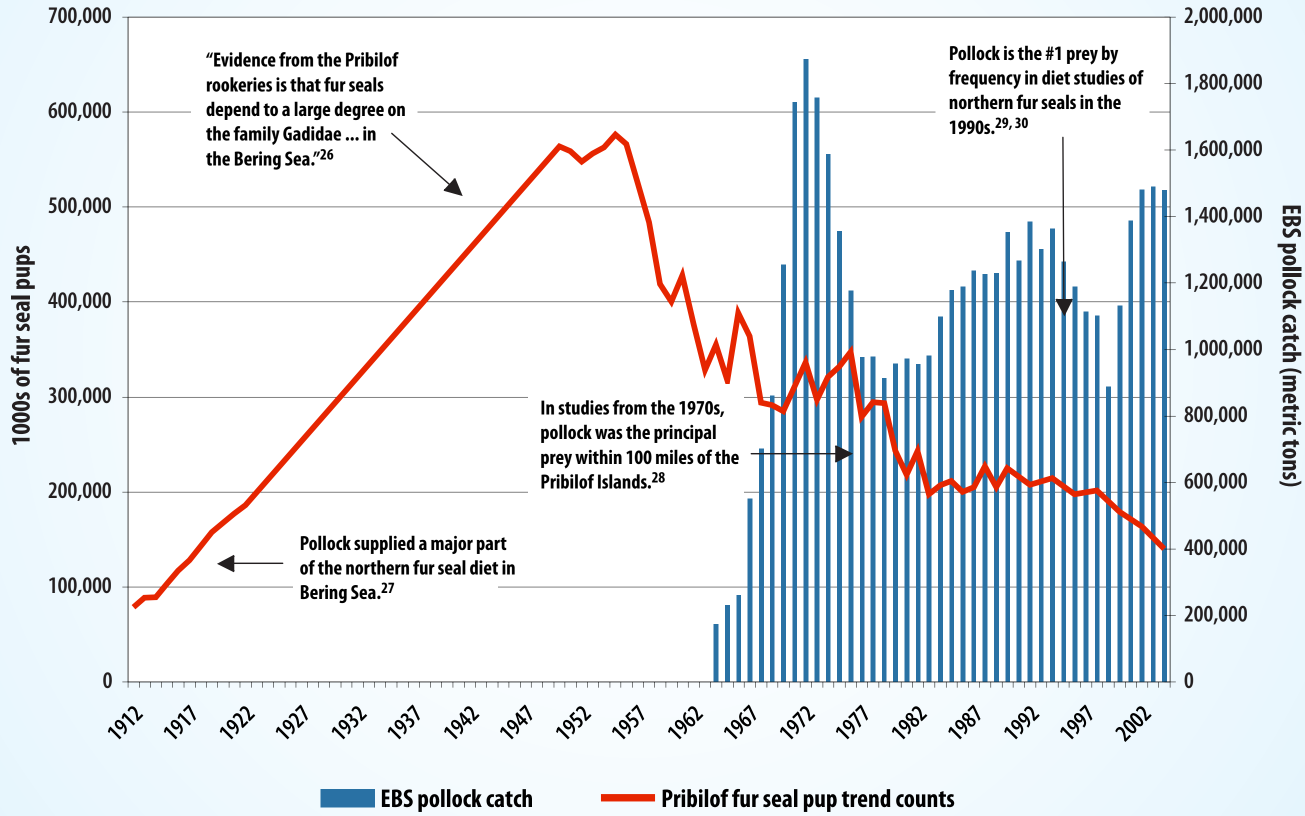
SOURCE: NMML (Seattle: Unpublished data); The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (2005).

This policy is the cornerstone of the North Pacific Fishery Management Council's (NPFMC – the body responsible for the management of federal fisheries off of Alaska's coast) claim of conservative management of the fishery resources. This approach results in allowable catch levels somewhat below the level that would be obtained from a strict MSY strategy.[22,23] However, this single-species approach to setting catch levels fails to consider the following question: *What are the effects on competing predators and other related and dependent species in the food web of seeking to reduce fully exploited spawning stocks by 60%, on average*? The NPFMC does *not* account for the needs of predators or other ecosystem-level considerations when setting groundfish catch levels.[24] Each stock's allowable catch levels are set in isolation from its relation to the ecosystem.[25]

The decline of Steller sea lions (*Eumetopias jubatus*) and northern fur seals (*Callorhinus ursinus*) in western Alaska has persisted over three decades, confounding scientists' expectations for these long-lived species. This decline, in waters shared with the pollock fishery, is in startling contrast to increasing trends for seals and sea lions from southeast Alaska to California.

The evidence that removal of selected species can cause ripple or "cascading" effects in the trophic structure of aquatic ecosystems is well established in the ecological literature, but links between cause and effect are notoriously difficult to establish scientifically in the open ocean environment, and hypotheses are nearly impossible to test.

FIGURE ES-4. PRIBILOF FUR SEAL PUP TRENDS WITH AND WITHOUT POLLOCK FISHING, 1912–2004

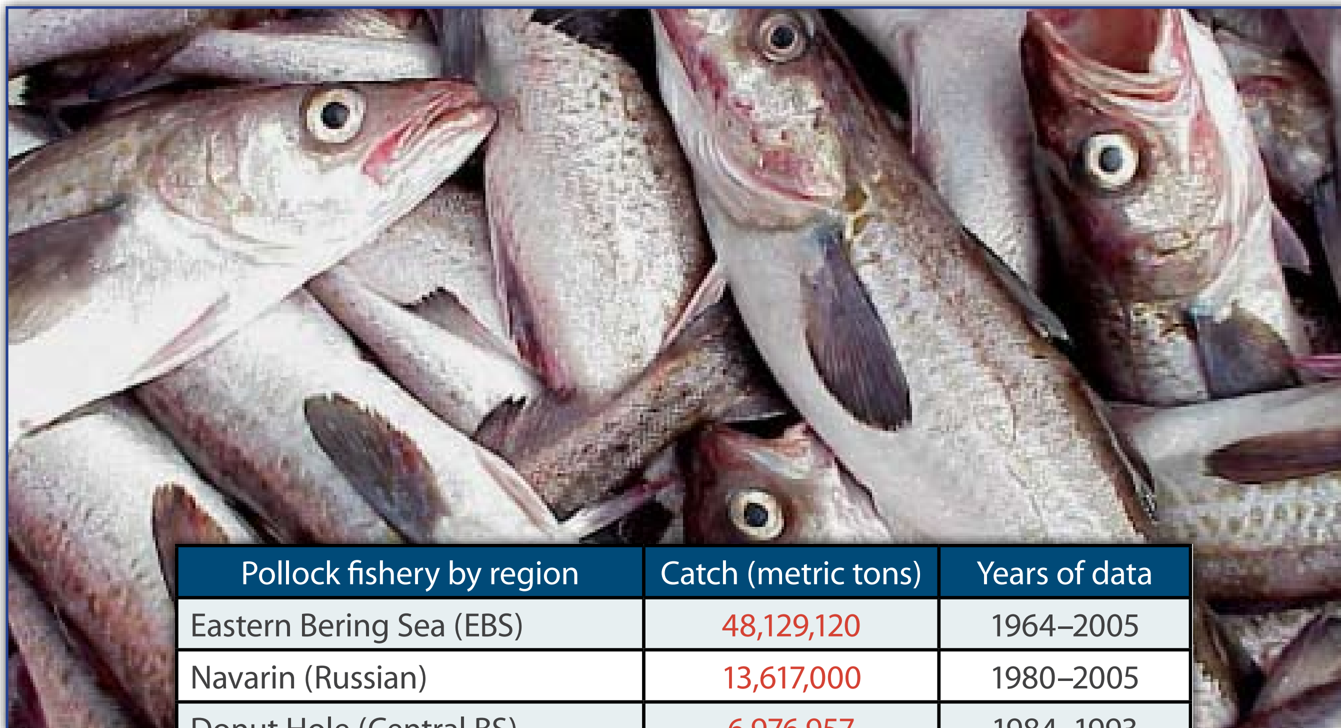


SOURCE: NMML (Seattle: Unpublished data); James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

While NMFS maintains claims of sustainability, such claims are made in the conventional single-species sense, and the ongoing declines of some of the North Pacific's most iconic species suggest that the limits of sustainability have been exceeded in an ecosystem context.

The pollock fishery reduces the overall availability of pollock to competing sea lions and fur seals by its very design. NMFS has acknowledged that this approach has the potential to reduce carrying capacity of competing pollock predators in the ecosystem.[31,32] They further concluded in 1998, and again in 2000, that the pollock fisheries are likely to jeopardize Steller sea lion survival and recovery, and adversely modify sea lion critical habitat, the defining feature of which is abundantly available prey.

The potential for conflict between large-scale commercial pollock fisheries and large populations of pollock predators in the North Pacific was recognized more than twenty years ago in the Final Environmental Impact Statement (EIS) for the Bering Sea/Aleutian Islands Fishery Management Plan and was deemed "especially acute with respect to the more than 2 million pinnipeds that inhabit the Bering Sea and Aleutians, particularly the northern sea lion and the northern fur seal."[33] A 1982 report to the NPFMC cited large increases in catches of Bering Sea pollock and other groundfish from a mere 12,500 tons in the early 1950s to over 2.2 *million* tons in the early 1970s, and specifically noted that large-scale groundfish fishery removals may reduce the carrying capacity for competing top predators such as the Steller sea lion.[34]



Pollock fishery by region	Catch (metric tons)	Years of data
Eastern Bering Sea (EBS)	48,129,120	1964–2005
Navarin (Russian)	13,617,000	1980–2005
Donut Hole (Central BS)	6,976,957	1984–1993
Gulf of Alaska	3,484,192	1970–2005
Aleutian Islands	975,724	1979–2005
Bogoslof/Aleutian Basin	920,636	1987–2001
Total all areas:	**74,103,629**	

SOURCE: The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions (2005).

TOTAL CATCH OF ALASKA POLLOCK SINCE 1964 = 74,103,629 METRIC TONS (163,368,860,493 POUNDS)

This is the equivalent weight of 855,334,348 average male American adults,[35] or nearly three times the entire American population.[36]

This total catch could circle the globe at the equator 1845 times.[37,38] It could reach to the moon and back over 96 times.[39]

The Alaska pollock caught in 2004 alone weighed over 1.5 million metric tons, or 3.4 billion pounds.[40] This is equal to the weight of over 17.8 million adult male Americans, or more than twice the population of New York City.[41]

If you were to lay these fish end to end, they would measure a length of 957,900 miles. This is equivalent to circling the globe at the equator approximately 38.5 times.

Photo: Freshly caught Alaska pollock © 2006 National Marine Fisheries Service/Alaska Fisheries Science Center.

ALASKA POLLOCK BIOLOGICAL CHARACTERISTICS

Evidence from the past suggests that the pollock fishery substantially reduced the average age, size, weight, and abundance of pollock in the Bering Sea in the 1970s[42] and in the Gulf of Alaska in the 1980s.[43]

LIFE SPAN OF ALASKA POLLOCK

- Pollock can attain ages of 12–16 years, and some may live considerably longer.
- The oldest recorded pollock was age 31.[44]
- The average age of Alaska pollock, however, was estimated in 1993 at about nine years.[45]

AVERAGE LENGTH AND WEIGHT OF ALASKA POLLOCK

- Reports from the beginning of the 20th century reflect that adult pollock could reach lengths of three feet (90 cm).[46]
- However, data from the 1980s indicated that pollock rarely attained lengths greater than two feet (60 cm), though some specimens reached lengths of about two and a half feet (70–80 cm).[47]
- The average 5-year-old pollock is about 18 inches in length (45 cm) and weighs about one and a half pounds (.6–.8 kg).[48]

SPAWNING AND FECUNDITY (EGG PRODUCTION) OF ALASKA POLLOCK

- Peak spawning varies from region to region, generally ranging from February to March or April in the Gulf of Alaska and southeastern Bering Sea, later in the northwestern Bering Sea.[49]
- Depending on location and latitude, spawning may occur any time from early winter to late summer in the Bering Sea.[50]
- Pollock are batch spawners, meaning that females release eggs every two to three days over a period of about a month.[51]
- As pollock females age and grow bigger and heavier, their egg-bearing potential increases substantially.[52]

SOURCE: Stacey Marz and Ken Stump, Concerns with the Alaska Pollock Fisheries Regarding the Marine Stewardship Council Sustainability Certification Review, (Prepared for Trustees for Alaska, 2002).

A NEW PARADIGM — SHIFTING THE BURDEN OF PROOF

The Steller sea lion crash and the accompanying declines of fur seals (see Figures ES 2–4), harbor seals, and some of the largest nesting colonies of fish-eating seabirds in the world are indicators of major change in the structure of the ecosystem in recent decades.[53] However, NMFS maintains that the information required to quantify fishery impacts on marine mammal food supplies and habitat would entail decades of sustained research, funding, and fieldwork. Given the inherent difficulties of research in this environment and the limits of research budgets, that scientific evidence could be a very long time coming. As noted by NMFS's own scientists, for the foreseeable future, marine science is likely to provide glimpses of underlying ecosystem mechanics rather than complete understanding.[54] And in the absence of baseline historical information that would allow a comparison between the current state of the ecosystem and an unfished environment, the causes of ecosystem changes in a complex system remain uncertain.[55]

The question then becomes: *Who bears the burden of proof in the meantime – the fisheries or the ecosystem?* All these uncertainties underscore the need for a more precautionary approach to fisheries management in the context of food web and habitat conservation, and illustrate why the agency's National Environmental Policy Act determinations of "insignificance" for fishery impacts on prey availability and spatial and temporal concentration of fisheries are inherently arbitrary.

Historically, the burden of proof has been on advocates of greater ecosystem protection to demonstrate that limits or constraints on fishing are justified. The management bias consistently avoids finding harm from fisheries activities even when the evidence strongly suggests otherwise, largely for economic reasons.[56]

Versions of ecosystem-based management now under consideration at the federal and regional levels would remain discretionary in terms of legal requirements and largely informational in terms of the fishery management decision-making process, requiring no explicit management actions. Ecosystem planning and management actions to address ecosystem impacts of fishing remain ancillary to the real business of the fishery management councils, which is to allocate fish and maximize economic benefits.

In the context of the Alaska pollock fisheries, perhaps the clearest examples of how the management system errs on the side of the fishing industry in the face of uncertainty can be seen in the inadequate response to needs of declining populations of pollock predators such as the Steller sea lion and northern fur seal. Another illustrative example is the absence of habitat reserves for pollock spawning grounds in the Bering Sea and Gulf of Alaska, both prime fishing grounds of the trawl fleet in the winter season. In both cases, the operating assumption is that current levels of fishing have no significant adverse impacts until proven otherwise, and the burden of proof on advocates of greater precaution is very high. Even when scientific evidence of adverse effects on the food web or habitat is brought forward, the inherent uncertainties are exploited by economic interests in the council process to deny, delay, or weaken any management measures that constrain fishing.

The difficulties of providing adequate protection to the pollock themselves and to dependent species in the pollock food web illustrate the obstacles to achieving ecosystem-based management under existing fisheries law. The fisheries-focused objectives, the narrow single-species scope of overfishing criteria based on maximum sustainable yield, the weak and discretionary habitat conservation mandate, the lack of explicit ecosystem conservation objectives or recognition of the precautionary principle, and the pervasive influence of the fishing industry in the decision-making process of the NPFMC all militate against an ecosystem-based approach worthy of the name.

The 1996 reauthorization of the MSA tasked NMFS with convening a panel to develop recommendations "to expand the *application* of ecosystem principles in fishery conservation and management activities."[57] The Ecosystem Principles Advisory Panel's (EPAP) report to Congress recommended an ecosystem-based management approach for fisheries and identified a broad fishery conservation and management goal of maintaining the health and sustainability of exploited ecosystems.[58]

"Our activities … are altering and threatening the structure and functioning of marine ecosystems — from which all marine life springs and upon which all living things, including humans, depend."

Pew Oceans Commission, *America's Living Oceans: Charting a Course for Sea Change. A Report to the Nation* (Arlington, VA: Pew Oceans Commission, 2003), vii.

Although some of the EPAP's principles, goals, and policies are currently applied in the North Pacific, the panel concluded that they are not applied comprehensively and systematically in any fishery management region, nor is there a clear mandate for this ecosystem approach. Thus the major recommendation of the EPAP Report to Congress was to mandate the development of an explicit fishery ecosystem plan (FEP) for ecosystems under the jurisdiction of the regional fishery management councils.

In September 2005, the Bush administration released its bill to reauthorize the Magnuson-Stevens Act. According to Commerce Secretary Carlos M. Gutierrez, the amended MSA would "elevate the importance of ecosystem-based management by authorizing the regional fishery management councils to develop ecosystem plans."[59] Importantly, the councils are authorized, *but not mandated*, to prepare fishery ecosystem plans.[60]

In this proposed version of ecosystem-based management, FEPs are envisioned as separate from the FMPs, discretionary in terms of legal requirements, and largely informational in terms of the council management decision-making process.[61] In other words, this version of ecosystem-based management requires no real changes to the existing way of doing business. Even more striking, if it wasn't for an amendment added six months later, the word "ecosystem" wouldn't appear at all in the 48-page bill introduced by Senator Ted Stevens (R-AK) in December 2005.

"U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including humans and nonhuman species and the environments in which they live."

U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century. Final Report* (Washington, DC: 2004), 6.

The goal of ecosystem-based fisheries management is to put ecosystem principles into *practice*, a desire also expressed in the Magnuson-Stevens Act.[62] In an ecosystem context, fishery sustainability may be understood as the levels and methods of fishing that are compatible with explicitly stated FMP objectives for preserving the productivity, nutrient dynamics, habitats, trophic structure, species richness, and resilience of the natural ecosystem. More broadly, NMFS defines ecosystem approaches to fisheries management as the means "whereby management programs consciously account for and address (1) all living resources within a specific marine area/ecosystem, including stocks targeted by fishing operations, non-target stocks, and the marine environment; and (2) all sources of environmental stress and factors influencing the ecosystem including fishing operations."[63]

Indian Paintbrush, fireweed, and daisies in bloom along shoreline of Unalaska Bay, Unalaska Island, Alaska © 2006 Alaska Stock.

BENEFITS OF MARINE RESERVES

Fishery related:

- Increase abundance, average size, reproductive output, and genetic diversity of target species
- Enhance fishery yield in adjacent areas
- Provide a simple and cost-effective management regime that is readily understood and enforced
- Guard against uncertainty and reduce probability of overfishing and fishery collapse
- Protect endangered species and marine mammals
- Provide opportunities for increased understanding of exploited marine systems
- Provide basis for ecosystem management

General:

- Increase habitat quality, species diversity, and community stability
- Provide undisturbed control sites for monitoring and assessing human impacts in other areas
- Create or enhance non-extractive, non-destructive uses, including tourism
- Reduce user conflicts
- Provide opportunities to improve public awareness, education, and understanding
- Create areas with intrinsic value

In the absence of clearer guidance and statutory requirements, however, an unspecified mandate to "account for and address" ecosystem considerations can be interpreted any number of ways by fisheries managers, whose primary objective under the MSA remains to be maximizing fisheries yield. The NPFMC may follow the advice of its scientific advisors, but that advice only comes within the narrow constraints of the mandate to maximize sustainable yield. Looking more broadly, there is a growing scientific consensus that "no take" marine reserves are a valuable tool to manage marine resources. While estimates for the most effective size of reserves range from 20-50% of a given ecosystem, less than half of one percent of U.S. waters is currently protected under the Marine Sanctuary Program – and much of this is open to some form of extractive industry. In the 900,000 square miles that are managed by the NPFMC, the amount of ocean closed entirely to fishing is zero.[64]

This is why the Pew Oceans Commission and U.S. Commission on Ocean Policy called for more basic reforms of the federal fisheries management system, including a new national ocean policy aimed at implementing an ecosystem approach for oceans and coasts, and a complete overhaul of the federal governance system to provide more effective guidance and coordination among federal agencies whose activities affect the marine environment.[65,66]


Point on Round Island Bristol Bay, Bering Sea, Alaska © 2006 Alaska Stock.

PUTTING ECOSYSTEM-BASED MANAGEMENT INTO PRACTICE

The steps proposed by Greenpeace and others in 2003 and in this report build upon these recommendations in an effort to redefine sustainability in an ecosystem context and operationalize ecosystem-based management in the water. Fishery ecosystem plans should be adopted for each major ecosystem, incorporating explicit principles, policies, guidelines, and regulations for ecosystem-based management into the fishery management plans. Under these ecosystem plans, conservation and management is defined as all the rules designed to:

- Protect and maintain healthy marine ecosystems, and restore degraded systems to healthy conditions, understood as ecosystems in which ecological processes, habitats, trophic levels, and productive capacity are comparable to an unexploited system, and the diversity of the native flora and fauna is preserved at the genetic, species, and community levels.
- Rebuild, restore, and maintain exploited fish stocks at high levels relative to an unfished condition in order to preserve the ecological relationships between the exploited, dependent, and related species in the food web.
- Establish a network of marine reserves to conserve fish and other wildlife habitats within a comprehensive plan for the protection of Essential Fish Habitat (EFH) of managed species, critical habitat of Endangered Species Act-protected species, known important habitats of Marine Mammal Protection Act-protected species, and habitats of management-defined categories of non-target and unmanaged species.
- Provide for commercial, recreational, and non-consumptive uses of the marine environment within the framework of 1–3.
- Avoid irreversible or long-term adverse effects on fishery resources and the marine environment.
- Transmit a legacy of healthy ecosystems to future generations.

Less than one half of one percent of marine habitats are protected — compared with 11.5 percent of global land area.

Alaska Oceans Program, <http://www.alaskaoceans.org/facts/fiftyfacts>.

These rules illustrate what fisheries management would look like if the burden of proof were truly shifted from the environment onto the fisheries. As such, they contrast sharply with the version of ecosystem-based management offered by NMFS as the "Preferred Alternative" Fishery Management Plan in the court-ordered Programmatic Supplemental EIS on the Alaska groundfish fishery management plans.[67] While consistent with the recommendations of the Pew Oceans Commission and U.S. Commission on Ocean Policy, this proposal for an ecosystem-based approach to management also contrasts sharply with the current proposals by Senator Stevens and the Bush administration.

There can no longer be any doubt about the enormous impact of large-scale industrialized fisheries on the ocean's fish populations, and, consequently, on marine ecosystems as a whole. Indeed, in an ocean that is increasingly affected by myriad human activities, from habitat destruction to toxic and nutrient pollution, to the all-pervasive threat of global warming, the need to address the destructive impacts of commercial fisheries has never been greater. To this point, however, the response to this growing crisis on the part of fisheries managers across the nation has been insufficient and reluctant. It is time for decisive action, for bold new steps requiring a radical makeover of the way in which fisheries are managed in this country. Following the recommendations laid out above would be the first, important steps toward the development and implementation of a sustainable fisheries management regime, for the benefit of fish populations, the fishing industry, and ocean ecosystems as a whole.

NOTES

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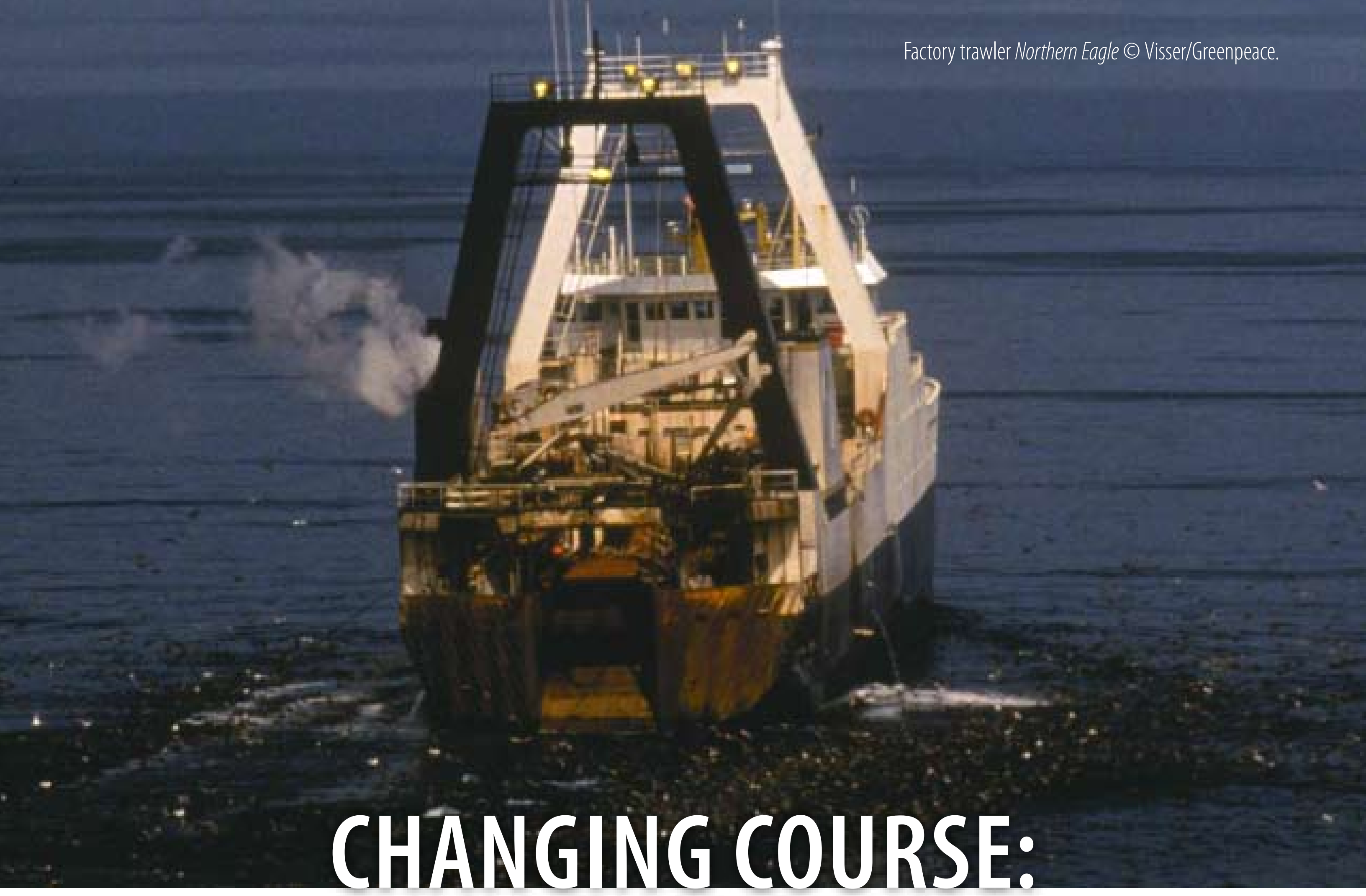


Factory trawler *Northern Eagle* © Visser/Greenpeace.

CHANGING COURSE:

THE NEED TO OVERHAUL OUR NATION'S FISHERIES LAW TO PROTECT MARINE ECOSYSTEMS

> *We are in a defining period for regional councils and fisheries management policy in general. Recommendations from the U.S. Oceans Commission on Ocean Policy will shape the debate about future policy regarding the management of our nation's marine fisheries. Congress will, I believe, listen closely to the Commission's recommendations.* — Senator Ted Stevens (Alaska)[1]

> *A comprehensive and coordinated national ocean policy requires moving away from the current fragmented, single-issue way of doing business and toward ecosystem-based management. This new approach considers the relationships among all ecosystem components, and will lead to better decisions that protect the environment while promoting the economy and balancing multiple uses of our oceans and coasts.* — U.S. Commission on Ocean Policy[2]

Anger at the depredations of the factory fishing fleets of Japan, Russia, Spain, and other "distant water" nations in the 1960s and 1970s spurred the passage of the Fishery Conservation and Management Act of 1976 (now known as the Magnuson-Stevens Act, or MSA). This legislation unilaterally extended U.S. sovereignty out to 200 nautical miles from shore by establishing an exclusive economic zone (EEZ[3]) and instituted the first-ever U.S. national fishery policy.

At a time when technological innovations were revolutionizing fishing and worldwide landings were increasing steadily, many predicted virtually limitless expansion of marine fisheries. Prevailing wisdom portrayed the oceans as an untapped resource and Congress shaped the new fisheries law accordingly, based on utilitarian commercial goals for resource extraction. Thus the primary objective was building a domestic fishing fleet capable of exploiting the resources in this vast new territory and displacing the distant water ships of that era.[4]

The Magnuson-Stevens Act ushered in a new era of fishery management and laid the groundwork for today's conflicts with environmental laws, in that it

- established a national charter for marine fisheries;
- sought to maximize economic benefits of the public resources;
- created eight regional fishery management councils (RFMCs) that placed stewardship of the marine wildlife within the EEZ in the hands of the fishing industry with virtually no representation from the non-fishing public;[5]
- defined "conservation and management" with reference to maintaining food supply and other products;[6]
- conceived of fish solely as food crop and economic opportunity; and
- ignored the fact that fish and other wildlife are members of complex ecological communities living in a highly dynamic environment that marine science is only beginning to understand.

As noted by the U.S. Commission on Ocean Policy, the MSA's supporters mistakenly assumed that the departure of the foreign fleets would solve America's fisheries problems.[7] But while the U.S. and other nations actively encouraged the modernization and expansion of domestic fishing fleets, worldwide landings of marine fish peaked in the 1980s far below the levels predicted in the 1960s.[8] The collapses of the centuries-old cod fisheries of Newfoundland and New England in the early 1990s were a barometer of the declining fortunes of fisheries everywhere, most of which are considered fully exploited or overexploited today.

We now know there are limits to the ocean's bounty of wild, free-ranging fish. The myth that the reproductive potential of marine fish is virtually inexhaustible has been discredited.[9] Assumptions about the resilience of wild fish populations to overexploitation are changing as we learn that many species fail to show signs of recovery from overfishing even years after fishing has ceased.[10] Yet fisheries management under the MSA fails to set effective limits on fishing in one fishery after another, species after species, area by area.

At the same time, the glut of fishing capacity in most fisheries only increases the pressure to fish harder, set more hooks, and trawl deeper in search of fishable concentrations. Modern technology has enabled fishermen to access areas of the ocean which served as *de facto* refuges from fishing in the past.[11,12] Sonar allows fishermen to find fish even in the blackness of the ocean depths. Advances in fishing gear have enabled them to plumb the deepest reaches of the continental shelf with hooks and trawl nets, and the efficiency of modern vessels vastly increases their capacity to locate, reach, and catch fish compared to earlier generations. Today, the fish have no place to hide — unless and until fishery management plans require no-take marine reserves.

> **"75 percent of the world's fish stocks are either being fully exploited or overfished."**
>
> Environment News Service, *Global Oceans Conference Finds Progress Slow* (Paris, France), January 31, 2006.

THE 1996 AMENDMENTS TO THE MAGNUSON-STEVENS ACT UNDERMINE SUSTAINABILITY IN AN ECOSYSTEM CONTEXT

Increased understanding of the vulnerability of fish, marine habitats, and ecosystem food webs has not translated into effective policies or management actions to sustain fisheries, much less to protect fish habitats or address the effects of fishing on marine food webs.

Despite amendments to the Magnuson-Stevens Act that establish rules designed to prevent overfishing and rebuild depleted fish stocks, overfishing remains a chronic problem in U.S. marine fisheries. A study by the National Academy of Public Administration concluded that the federal fishery management system is in disarray.[13] The regional fishery management councils have exploited loopholes and weaknesses in the law to avoid imposing restrictions on catches. Additional MSA amendments aimed at reducing the impacts of fishing gear on EFH have proven weak and discretionary, subject to the strong opposition of some fishing interests who fear that protective measures will put them out of business. At every turn, the law is peppered with qualifying phrases (e.g., "to the extent practicable") that were intended to provide flexibility, but instead permit councils to avoid constraining fishing.

Moreover, the MSA focuses on single-species management of target fish stocks, which fails to account for the impacts of the fisheries on marine food webs and habitats in an ecosystem context. The law does not require managers to set catch levels with adequate and precautionary consideration to the needs of marine wildlife that rely on the same fish that fisheries are targeting.

Thirty years after Congress passed the Magnuson-Stevens Act, and ten years after the 1996 Sustainable Fisheries Act amendments, U.S. fisheries management is in disarray and sustainability remains an elusive goal.

- **Many regional fishery management councils fail to comply with existing MSA requirements to specify overfishing criteria, set catch limits below overfishing thresholds, rebuild overfished stocks, minimize bycatch, and protect essential fish habitat.**
- **The regional governance structure is replete with conflicts of interest and lacks accountability for failure to comply with existing laws.**
- **The tradeoffs between competing objectives in the MSA are decided by a body that is not representative of the broader public interest and is biased heavily in favor of self-interested commercial utilization of the public resource.**
- **The fishery-focused definition of "conservation and management" in the MSA does not safeguard the long-term viability of protected species, food webs, and habitats.**
- **The measure of "overfishing" in the federal fisheries law, based on conventional yield-maximizing goals for single species, fails to account for the impacts on marine food webs and habitats in an ecosystem context.**
- **Fundamental conflicts among objectives for ecosystem protection in environmental laws such as the Marine Mammal Protection Act and the Endangered Species Act and the fishery management goals under the MSA remain unresolved.**
- **The MSA does not require fishery managers to err on the side of conservation over commerce when dealing with the uncertainties and risks of fisheries science.**

RETHINKING FISHERIES SUSTAINABILTY

For the first time in ten years, Congress is preparing to reauthorize and amend the Magnuson-Stevens Act. Reauthorization comes on the heels of clarion calls to reform fisheries management and national ocean policy and governance to require a more holistic, ecosystem-based approach to fisheries management.[14]

> **The message is clear: The nation needs to move beyond the myopic, single-species approach to fishery sustainability in the MSA. Instead, fisheries management and ocean policy must protect the marine ecosystems on which fish depend.**

Building on the recommendations of previous reports, the final report of the U.S. Commission on Ocean Policy calls for a new national ocean policy aimed at implementing an ecosystem approach for oceans and coasts, and proposes a complete overhaul of the federal governance system to provide better guidance and coordination among federal agencies whose activities affect the marine environment.[15,16]

Sustainability involves more than avoiding overfishing the target fish stock. The Magnuson-Stevens Act defines overfishing as a "level of fishing mortality that jeopardizes the capacity of a fishery to produce maximum sustainable yield on a continuing basis."[17] In other words, as long as a single fish stock produces the theoretical maximum sustainable yield,[18] the fishery is considered "sustainable" regardless of its effects on other species or habitats. Fishing at a level that does not amount to "overfishing" under this definition does not mean that such fishing does not negatively impact the ecosystem. Furthermore, setting levels with singular focus on the yield of the target fish stock does not ensure that overfishing will be avoided because there is so much uncertainty in the stock assessment advice provided by federal fisheries scientists. Sustainability in marine fisheries will remain elusive as long as the management approach to overfishing fails to address the relevant ways in which fishing impacts the marine environment. Through her proposed National Oceans Protection Act of 2005 (NOPA), Senator Barbara Boxer (D-CA) proposed to remedy the shortcomings in the present fisheries law by amending the purposes of the MSA to include the central recommendation of the U.S. Commission on Ocean Policy, an overarching objective for ecosystem-based fisheries management:

> *[T]he principal objective of United States fishery policy in all ocean waters of the United States [is] the protection, maintenance, and restoration of the health, integrity, productive capacity, and resilience of the marine ecosystems upon which long-term health and viability of fisheries depend and in cases of conflict between this objective and any other objective or in cases where information is uncertain or inconclusive, the principal ecological objective shall take precedence.*[19]

In September 2005, the Bush administration released its bill to reauthorize the Magnuson-Stevens Act. According to Commerce Secretary Carlos M. Gutierrez, the amended MSA would "elevate the importance of ecosystem-based management by authorizing the regional fishery management councils to develop ecosystem plans."[20] Importantly, the councils are authorized, *but not mandated*, to prepare fishery ecosystem plans (FEPs).[21]

"U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including humans and nonhuman species and the environments in which they live."

U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century. Final Report* (Washington, DC: 2004), 6.


Humpback whale, Alaska © Greenpeace/Merjenburgh.

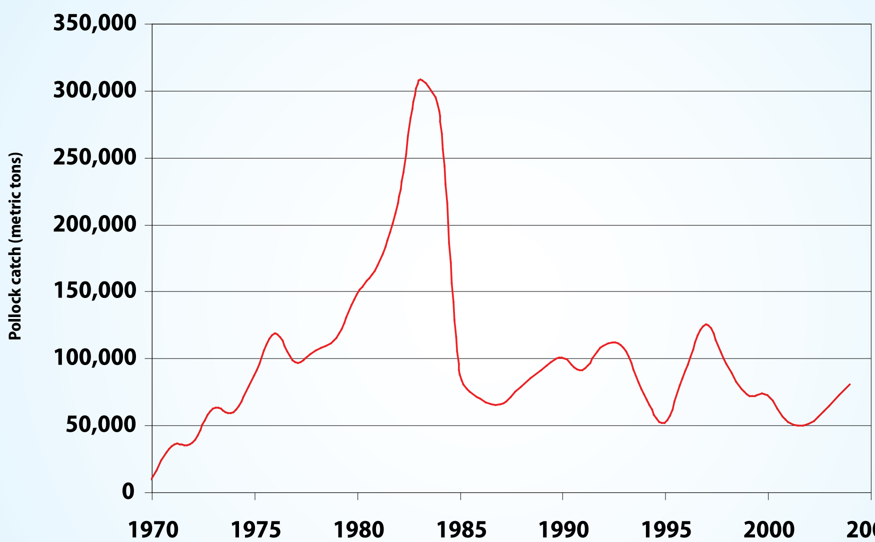
In this proposed version of ecosystem-based management, FEPs are envisioned as separate from fishery management plans, discretionary in terms of legal requirements, and largely informational in terms of the council management decision-making process. In other words, this proposal requires no real changes to the existing way of doing business. Even more striking, if it wasn't for an amendment added six months after its initial introduction, the word "ecosystem" wouldn't appear at all in the 48-page MSA reauthorization bill introduced by Senator Ted Stevens (R-Alaska) in December 2005.

The limits of sustainability as defined in the Magnuson-Stevens Act are illustrated by the Alaska pollock fishery, the nation's largest fishery, as well as the largest food fishery in the world. However, the fishery-focused definition of "conservation and management" in federal fisheries law fails to account for the impacts of the fisheries on marine food webs and habitats in an ecosystem context. The Alaska pollock fishery typifies these shortcomings.

The National Research Council (NRC) highlighted the failure of the North Pacific Fishery Management Council (NPFMC), the body responsible for the management of Alaska's 900,000 nm^2 EEZ, to address the needs of ecosystem consumers of pollock, such as the Steller sea lion and northern fur seal, nearly a decade ago in a report on the Bering Sea ecosystem:

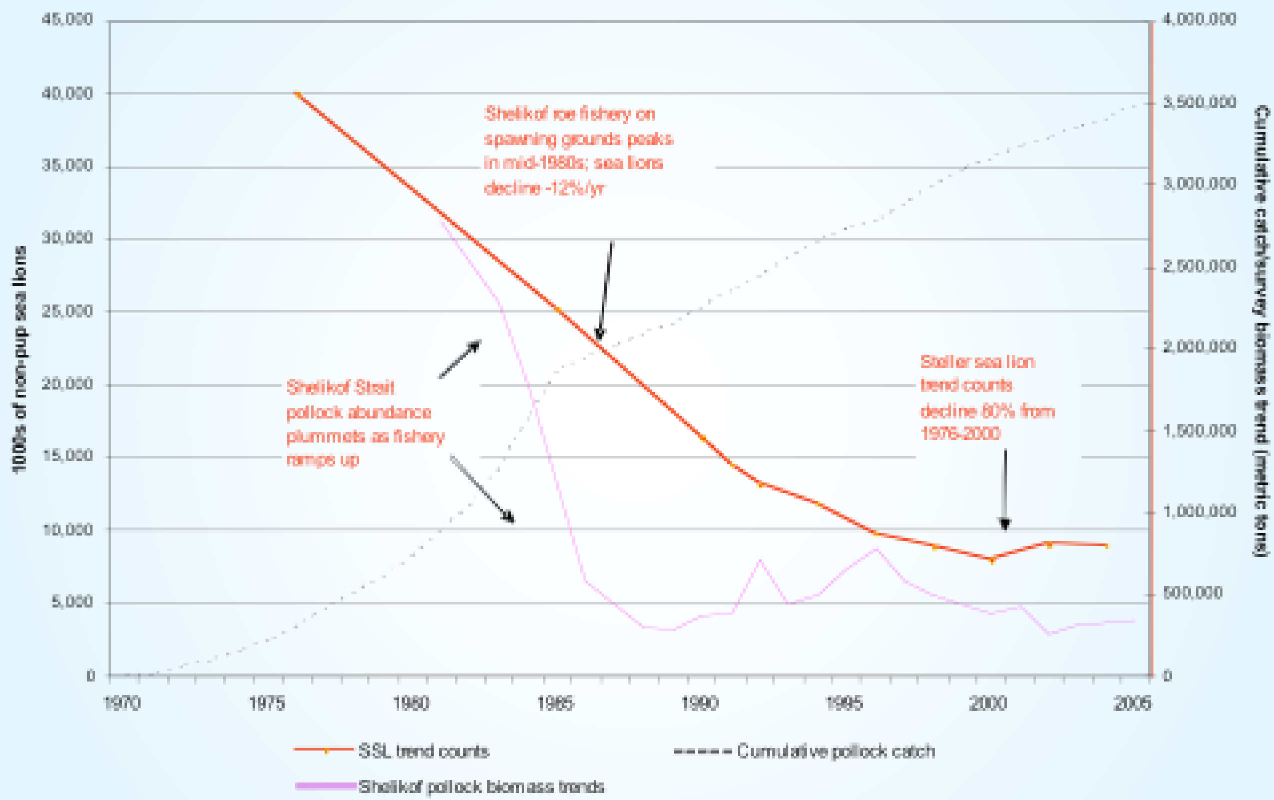
> *Fundamental conflicts between the usual goals of maximizing yields in marine fisheries management and the goals of the Endangered Species Act, Marine Mammal Protection Act, and National Environmental Policy Act remain unresolved even at the federal level in the National Marine Fisheries Service, as illustrated by the present groundfish management by the North Pacific Fishery Management Council, which does not explicitly orient management to provide additional food resources for the threatened Steller sea lion or for other declining marine mammals and seabirds in the Bering Sea and Gulf of Alaska.*[22]

FIGURE 1. HISTORICAL POLLOCK CATCH IN GULF OF ALASKA, 1970–2004



SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

FIGURE 2. CUMULATIVE GULF OF ALASKA POLLOCK CATCH WITH ACCOMPANYING DECLINES IN SHELIKOF POLLOCK BIOMASS AND STELLER SEA LION TREND COUNTS



SOURCE: NMML (Seattle: Unpublished data); Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

Threats posed by the Alaska pollock fishery to the ecosystem have been a decades-long source of concern, controversy, and debate. Despite lip service to ecosystem considerations, however, the managers of the pollock fishery have taken largely token measures to eliminate these threats while raising the Bering Sea pollock Total Allowable Catch (TAC[23]) substantially since 2000.[24] Key indicators of fishery performance in relation to the ecosystem – such as the concentration of the catch on vulnerable pollock spawning grounds, in Endangered Species Act-designated Steller sea lion critical habitat, and in unprotected foraging habitat of female northern fur seals raising pups on the Pribilof Islands – are not improved from the late 1990s, when Greenpeace and allies sought relief in the courts. Similarly, NMFS and the NPFMC have not acted on an independent scientific panel report to the NPFMC that found that the current "harvest policy" is likely to reduce the availability of prey to other consumers in the ecosystem.[25] Instead, the Bering Sea pollock take is at historically high levels, while the much smaller Gulf of Alaska pollock fishery continues to exploit a vastly diminished stock.

The Alaska pollock fishery is symptomatic of the problems with conventional U.S. fisheries management, not the solution to those problems. In the short 40-year history of this "factory fishery," numerous pollock reproductive centers have been depleted and major pollock predators have declined precipitously, indicating major changes in the structure of the pollock-based food web. From the single-species perspective of fishery managers, the resource is "healthy" because overall fishery yields remain high, but the cumulative ecosystem-wide changes that have accompanied the development of this factory fishery (see Figure 2) suggest that the limits to real sustainability have been exceeded.

NOTES

CHANGING COURSE

[1] Senator Ted Stevens (R-Alaska), Keynote address to the Managing Our Nation's Fisheries Conference, Washington D.C., November 13, 2000.

[2] U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century. Final Report* (Washington, DC: 2004).

[3] Exclusive Economic Zone (EEZ), extending 200 nautical miles from U.S. coastlines.

[4] In a telling 1968 address to the University of Washington School of Fisheries Conference on the Future of the United States Fishing Industry, Senator Magnuson of Washington State memorably said, "Let us not study our resources to death; let us harvest them."

[5] *U.S. Code* 16 § 1852 (b).

[6] *U.S. Code* 16 § 1802 (5).

[7] U.S. Commission on Ocean Policy, *Ocean Blueprint,* 275.

[8] Ibid., 274. The U.S. Stratton Commission report (1969) predicted that worldwide landings could increase from approximately 60 million t/yr in 1966 to as much as 440-550 t/yr.

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[10] Jeffrey A. Hutchings, "Collapse of Marine Fisheries," *Nature* 406 (1994): 882-885.

[11] Les Watling and Elliott A. Norse, "Disturbance of the Seabed by Mobile Fishing Gear: A Comparison to Forest Clearcutting," *Conservation Biology* 12 (1998): 1180-1197.

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[13] National Academy of Public Administration, *Courts, Congress, and Constituencies: Managing Fisheries by Default* (Washington, DC: 2002).

[14] Examples include: Ecosystem Principles Advisory Panel 1999; National Research Council 1999; Pew Oceans Commission 2003; and U.S. Commission on Ocean Policy 2004.

[15] Ecosystem Principles Advisory Panel, *Ecosystem-Based Fishery Management: A Report to Congress by the Ecosystem Principles Advisory Panel* (Washington, DC: U.S. Department of Commerce, NOAA, NMFS, 1999), 27.

[16] Pew Oceans Commission, *America's Living Oceans: Charting a Course for Sea Change. A Report to the Nation* (Arlington, VA: Pew Oceans Commission, 2003). The Pew Oceans Commission reached a similar conclusion about the shortcomings of fisheries management under the Magnuson-Stevens Act and recommended basic reforms of the federal fisheries law and ocean management system. The Pew Commission outlined four broad objectives aimed at restructuring fisheries management around the protection of marine ecosystems:

- Management of fisheries, marine mammals, and other marine life requires a unified, ecosystem-based approach.
- Marine life management, including fisheries management, should be mandated to conserve healthy marine ecosystems, allow only sustainable uses, and recognize non-consumptive uses and values.
- For better coordination and greater accountability, one agency should have responsibility for marine life management (including fisheries), and that should be the only responsibility of that agency.
- Federal marine life management should make it easy for all interested members of the public and regulated communities to participate in decision-making.

[17] *U.S. Code* 16 § 1802 (29).

[18] Maximum sustainable yield (MSY)—defined by the National Marine Fisheries Service as "the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions." From *NOAA Fisheries Strategic Plan Glossary of Terms*, http://www.nmfs.noaa.gov/om2/glossary.html (accessed May 6, 2006).

[19] *National Oceans Protection Act of 2005*, S.1224, § 311 (a)(1).

[20] http://www.nmfs.noaa.gov/docs/magnuson-release.pdf (accessed May 6, 2006).

[21] http://www.eco-law.org/Documents/MSA%20Reauthorization%20bill_Final%20(12-1-05).pdf (accessed May 6, 2006).

[22] Committee on the Bering Sea Ecosystem, NRC, *The Bering Sea Ecosystem*. (Washington, DC: National Academy Press, 1996), 24.

[23] The total allowable catch (TAC) is a catch limit set for a particular fishery, generally for a year or a fishing season.

[24] The TAC for Bering Sea pollock in 2006 is 1,485,000 metric tons, a 30% increase from the 1,139,000 metric ton TAC for 2000.

[25] Daniel Goodman, Marc Mangel, and Graeme Parks, et al., *Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Fishery Management Plans—Draft report* (Anchorage: North Pacific Fishery Management Council, 2002).

POLLOCK'S CENTRAL ROLE
IN THE NORTH PACIFIC FOOD WEB

It seems extremely unlikely that the productivity of the Bering Sea ecosystem can sustain current rates of human exploitation as well as the large populations of all marine mammal and bird species that existed before human exploitation — especially modern exploitation — began.[1]

A common thread linking marine predators in western Alaska is their reliance on walleye pollock (*Theragra chalcogramma*), a hake-like member of the cod family whose range extends across the North Pacific Rim from Puget Sound to the Sea of Japan. Pollock's central importance as a forage fish in the Bering Sea food web has been known since the 19th century, hence pollock's scientific name, *Theragra*, from the Greek *Ther* (beast) and *agra* (prey or food).[2] Pollock is consumed at every stage of its life cycle by mammals, birds, and fishes.

Pollock is the dominant prey fish in the eastern Bering Sea,[3] and was the dominant prey of groundfish and Steller sea lions in the Gulf of Alaska during the 1990s.[4,5] Groundfish predators of pollock include some of the most abundant and highly valued species in the Bering Sea and Gulf of Alaska: Pacific halibut, Greenland turbot, arrowtooth flounder, flathead sole, Pacific cod, and sablefish, as well as Pacific sandfish, shortspine thornyhead, great sculpin, and Alaska skate.[6] Major marine mammal predators of pollock include the endangered Steller sea lion, depleted northern fur seal, depleted Pacific harbor seal, spotted and ribbon seals in the Bering Sea, harbor and Dall's porpoises, and fin, minke, and humpback whales.[7] Seabird predators of pollock include some of the world's largest nesting colonies of kittiwakes, murres, and puffins in the Pacific Ocean, in addition to fulmars, guillemots, cormorants, shearwaters, murrelets, and auklets.

WALLEYE POLLOCK PREDATORS IN THE NORTH PACIFIC

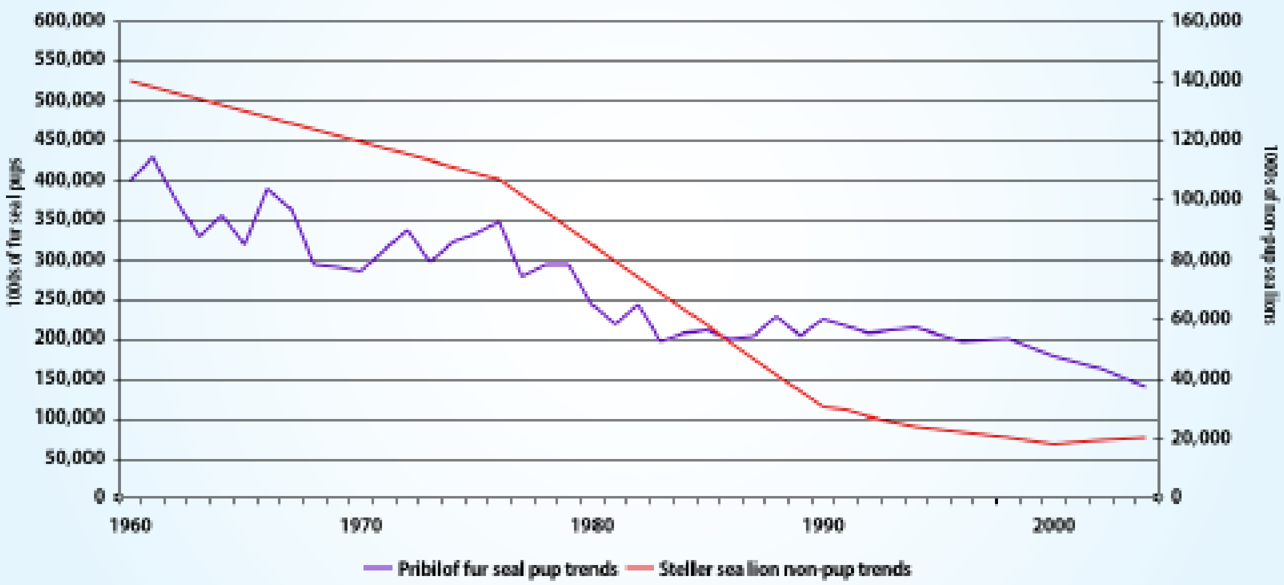
Marine Mammals	Seabirds	Fishes
Northern fur seal *Callorhinus ursinus*	**Tufted puffin** *Fratercula cirrhata*	**Pacific halibut** *Hippoglossus stenolepsis*
Steller sea lion *Eumetopias jubatus*	**Horned puffin** *Fratercula corniculata*	**Greenland turbot** *Reinhardtius hippoglossoides*
Pacific harbor seal *Phoca vitulina richardsi*	**Black-legged kittiwake** *Rissa tridactyla*	**Flathead sole** *Hippoglossoides elassodon*
Spotted seal *Phoca largha*	**Red-legged kittiwake** *Rissa brevirostris*	**Arrowtooth flounder** *Atheresthes stomias*
Ribbon seal *Phoca fasciata*	**Common murre** *Uria aalge*	**Sablefish** *Anoplopoma fimbria*
Ringed seal *Phoca hispida*	**Thick-billed murre** *Uria lomvia*	**Pacific cod** *Gadus macrocephalus*
Harbor porpoise *Phocoena phocoena*	**Northern fulmar** *Fulmarus glacialis*	**Sculpin** *Cottidae* species
Dall's porpoise *Phocoenoides dalli*	**Pigeon guillemot** *Cepphus columba*	**Pacific sandfish** *Trichodon trichodon*
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	**Pelagic cormorant** *Phalacrocorax pelagicus*	**Alaska skate** *Bathyraja parmifera*
Fin whale *Balaenoptera physalus*	**Short-tailed shearwater** *Puffinus tenuirostris*	**Shortspine thornyhead** *Sebastolobus alascanus*
Sei whale *Balaenoptera borealis*	**Marbled murrelet** *Brachyramphus marmoratus*	**Walleye pollock** *Theragra chalcogramma*
Minke whale *Balaenoptera acutorostrata*		
Humpback whale *Megaptera novaeangliae*		
Killer whale *Orcinus orca*		
Beluga whale *Delphinapterus leucas*		

Steep declines of top predators in the pollock food web (including Steller sea lions, northern fur seals, Pacific harbor seals, and some seabird species) have accompanied the explosive growth of the pollock fishery since the 1960s, indicating major changes in the structure of the ecosystem.[8] The threats that the pollock fishery poses to pollock consumers in the ecosystem have been a lightning rod for controversy and conflict in scientific, political, and legal arenas for nearly two decades.

The potential for conflict between large-scale commercial pollock fisheries and large populations of pollock predators in the North Pacific was recognized nearly 25 years ago. The Final Environmental Impact Statement (EIS) for the Bering Sea/Aleutian Islands Fishery Management Plan stated that this potential was "especially acute with respect to the more than 2 million pinnipeds that inhabit the Bering Sea and Aleutians, particularly the northern sea lion and the northern fur seal."[9] In a 1982 report to the NPFMC, marine mammal scientists noted that catches of pollock and other groundfish off Alaska increased from negligible levels in the early 1950s to over 2.2 million tons in the early 1970s, compelling them to warn that large-scale fishery removals may reduce the environment's carrying capacity for competing predators.[10]

Long-term trends in fur seal and sea lion populations across southwestern Alaska seem to bear out those early warnings, as illustrated in Figure 3.

FIGURE 3. DECLINES IN NORTHERN FUR SEAL AND STELLER SEA LION POPULATIONS IN WESTERN ALASKA, 1960–2004



SOURCE: NMML, NMFS.

Concern that the factory fishery for pollock has caused or contributed to declines in top predators and triggered cascading effects through the North Pacific ecosystem has created a rich environment for hypotheses and controversy.[11] Evidence that removal of selected species can cause ripple, or cascading, effects in the trophic structure of aquatic ecosystems is well established, but links between cause and effect are notoriously difficult to establish in the open ocean environment and hypotheses are nearly impossible to test. The NPFMC and the pollock industry have exploited this uncertainty to undermine efforts to remedy the effects of the pollock fishery on endangered Steller sea lions and other consumers of pollock.

Mainstays in the northern fur seal and Steller sea lion diet, such as walleye pollock, Atka mackerel, and Pacific cod, have become the targets of rapidly expanding groundfish fisheries pioneered by Japanese and Russian distant water factory ships in the 1960s. The concentration of these giant trawl fisheries in areas designated as critical habitat of the endangered Steller sea lion created a legal showdown between the requirements of the Endangered Species Act and the largest fisheries in the United States in the late 1990s, when NMFS concluded twice (1998 and 2000) that the pollock fishery is likely to both jeopardize the survival and recovery of Steller sea lions and to modify their critical habitat, the most important feature of which is abundantly available prey.

NMFS and the NPFMC assert that no groundfish stocks are overfished in the North Pacific under the technical terms of the definition in the groundfish management plans, based on stock assessments that rely on computer simulated population dynamics. However, the growing gulf between the official claims of sustainability in the conventional single-species sense and the ongoing declines of some of the North Pacific's most iconic species suggests that the limits of sustainability have already been exceeded in an ecosystem context.

NOTES

POLLOCK'S CENTRAL ROLE

[1] Committee on the Bering Sea Ecosystem, Polar Research Board, and Commission on Geosciences, Environment and Resources, et al., *The Bering Sea Ecosystem* (Washington, DC: National Academy Press, 1996), 4.

[2] David Jordan and B.W. Evermann, "The Fishes of North and Middle America: A Descriptive Catalogue of the Species of Fish-Like Vertebrates Found in the Waters of North America North of the Isthmus of Panama," *Bulletin of U.S. National Museum* 47 (1898).

[3] NMFS, *Alaska Groundfish Fisheries Final Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2004) [report hereafter cited as *Final PSEIS*]; Laevastu and Larkins (1981) estimated that annual pollock consumption by marine mammals in the eastern Bering Sea was comparable to the commercial catch; Using data from 1985-1988, Livingston (1993) estimated total groundfish consumption of eastern Bering Sea pollock ranging from 3.86 million metric tons in 1985 (following the appearance of a large 1984 year class) to 920,000 metric tons in 1988.

[4] Mei-sun Yang and Mark W. Nelson, *Food Habits of the Commercially Important Groundfishes in the Gulf of Alaska in 1990, 1993, and 1996*, NOAA Technical Memorandum NMFS-AFSC-112 (Washington, DC: U.S. Department of Commerce, NOAA, NMFS, 2000).

[5] Elizabeth Sinclair and Tonya Zeppelin, "Seasonal and Spatial Differences in Diet in the Western Stock of Steller Sea Lions (*Eumetopias jubatus*)," J*ournal of Mammalogy* 83 (2002): 973-990.

[6] NMFS, *Final PSEIS*.

[7] Ibid.

[8] Richard Merrick, "Current and Historical Roles of Apex Predators in the Bering Sea Ecosystem," *Journal of Northwest Atlantic Fisheries Science* 22 (1997): 343-355.

[9] NPFMC, NMFS, *Final Environmental Impact Statement for the Bering Sea/Aleutian Islands Groundfish Fishery Management Plan* (1981).

[10] Lloyd Lowry, Donald Calkins, and G.L. Swartzman, et al., "Feeding Habits, Food Requirements and Status of Bering Sea Marine Mammals (Anchorage: NPFMC, 1982), 148.

[11] Examples include: Springer 1992; Fritz et al. 1995; Committee on the Bering Sea Ecosystem 1996; Merrick 1997; Estes et al. 1998; Francis et al. 1998; Fritz and Ferrero 1998; Anderson and Piatt 1999; Trites et al. 1999; NMFS 1998, 2000; Hunt et al. 2002; Springer et al. 2003; Benson and Trites 2003; Fritz and Brown 2005; Dew and McConnaughey 2005.

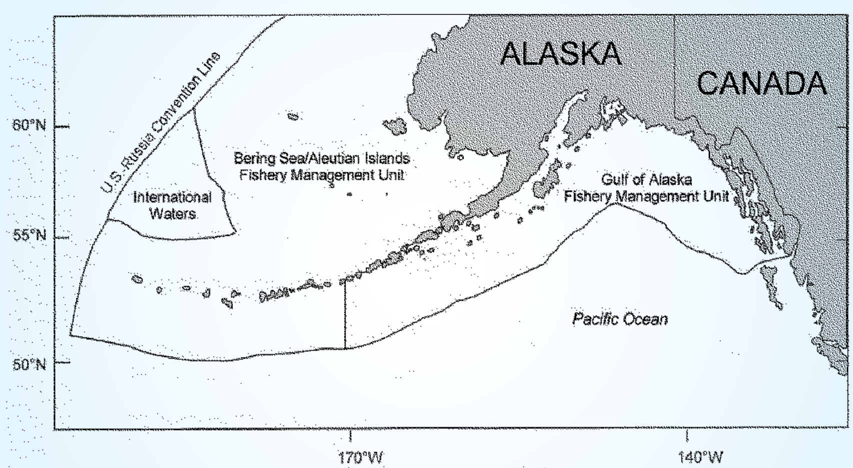
Factory trawler *Northern Eagle* fishing for pollock in the Bering Sea
© Greenpeace/Visser.

FACTORY FISHING ON THE LAST FRONTIER:
THE ALASKA POLLOCK FISHERY

The U.S. territorial seas off Alaska's 33,000-mile coastline are twice the size of the combined East and West Coast EEZs and include some of the most productive marine ecosystems in the world. Historically, these ecosystems have supported some of the largest assemblages of marine mammals and seabirds in the world, and – since the 1960s – some of the planet's largest fisheries for bottom-tending "groundfish," dominated by the Alaska pollock fishery. The biggest source of this bounty is the extensive continental shelf in the eastern Bering Sea, accounting for about half of the marine fish and shellfish caught in the United States annually.

Pollock has accounted for over 70% of all groundfish landings off Alaska since the 1960s (approximately 52 million tons, more than 114 billion pounds),[1,2] and another 20 million tons of pollock have been taken from adjacent international waters of the central Bering Sea "Donut Hole" and Russian waters off Cape Navarin in the northwestern Bering Sea (see Table 1).

FIGURE 4. MAP OF BERING SEA/ALEUTIAN ISLANDS AND GULF OF ALASKA



SOURCE: NMFS, *Alaska Groundfish Fisheries Final Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2004).

Pollock was long regarded as a commercially worthless "scrap" fish by American fishermen who targeted salmon, halibut, herring, and crab. Pollock's potential as a cheap and plentiful protein source was only realized in the early 1960s when

TABLE 1. TOTAL CATCH OF ALASKA POLLOCK FISHERY BY REGION

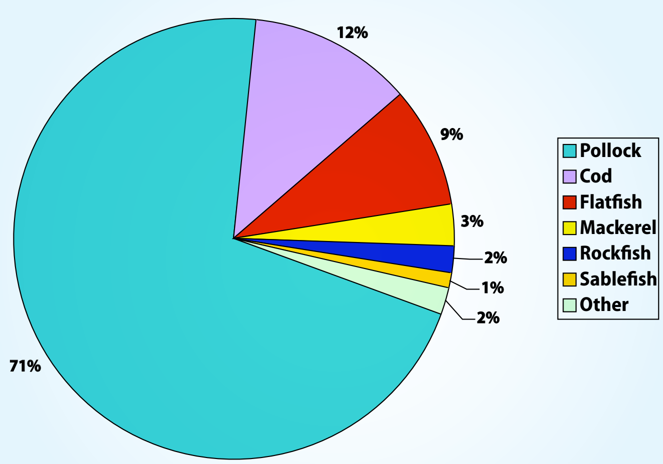
Pollock fishery by region	Catch (metric tons)	Years of data
Eastern Bering Sea (EBS)	48,129,120	1964–2005
Navarin (Russian)	13,617,000	1980–2005
Donut Hole (Central BS)	6,976,957	1984–1993
Gulf of Alaska	3,484,192	1970–2005
Aleutian Islands	975,724	1979–2005
Bogoslof/Aleutian Basin	920,636	1987–2001
Total all areas:	**74,103,629**	

SOURCE: The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (2005).

Japanese factory trawlers introduced a process for reducing pollock's white flesh into a protein paste called surimi. The scale of the modern pollock fishery has no historical precedent in the region, with recent annual catches of approximately 1.5 million metric tons (3.3 billion pounds). This accounts for fully 70–75% of the annual Bering Sea groundfish catch and nearly one-third of all marine fish caught in U.S. waters annually.

In the 1990s, as cod stocks in the North Atlantic collapsed from overfishing, pollock became a popular whitefish substitute for cod in the global seafood trade. Today, pollock is widely marketed in Asia, Europe, and North America as surimi (imitation crabmeat), fast food fish fillets, and frozen fish sticks, in addition to the highly lucrative market for pollock roe (fish eggs). While fishery managers point to the enormous yields and revenues generated by the Alaska pollock fishery as proof of its sustainability, the NRC recognized nearly a decade ago that several regions where pollock were once abundant have been heavily exploited and that the pollock stocks in those regions have suffered major declines.[3] Intense concentration of the pollock fisheries on spawning aggregations since the 1980s has been accompanied by serial declines in pollock abundance in the Gulf of Alaska (1980s), Bogoslof/Aleutian Basin (1987–1992), and Aleutian Islands (1990s), leading to the closure of the latter two areas in the 1990s. Overall yields have remained high throughout the period of U.S. management, but three of the four defined stocks in the fishery management plans remain at or near historic low abundance levels today.

FIGURE 5. PERCENT OF EASTERN BERING SEA GROUNDFISH CATCH BY SPECIES, 2004



SOURCE:The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (2005).

Fishery managers portray Alaska pollock abundance as reaching all-time highs under the stewardship of the NPFMC, but history suggests otherwise. Looking at the pollock fishery over the past 25 years, a pattern emerges of depletion in outlying population centers followed by contraction of the fishery toward the center of pollock's range in the eastern Bering Sea. With the Aleutian Basin and Aleutian Islands closed to directed pollock fishing due to low abundance, and the Gulf of Alaska experiencing historic low pollock abundance and lower TAC levels, 96% of all pollock caught off Alaska are now taken from the eastern Bering Sea. On the Russian side of the Bering Sea, only the Navarin region has continued to sustain high levels of fishing, and those pollock are believed by many to be of eastern Bering Sea origin — in which case, the stock is subjected to two independent sources of fishing mortality in two management regions.[4]

TABLE 2. 2004 PRODUCTION AND GROSS VALUE OF POLLOCK PRODUCTS BY PRODUCT TYPE

Product	Quantity (metric tons)	Value (U.S. dollars)
Fillets	162,160	$362,800,000
Roe – only approximately 5% of product weight, but one-third of overall pollock product value	26,310	$344,700,000
Surimi	186,720	$289,800,000
Fish meal	56,110	$43,200,000
Mince fish	19,860	$25,900,000
Head & gut	18,250	$17,900,000
Other	18,520	$11,300,000
Whole fish	3,570	$2,700,000
Total	**491,500**	**$1,098,300,000**

SOURCE: Terry Hiatt, ed. "Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska and Bering Sea/Aleutian Islands Area: Economic Status of the Groundfish Fisheries off Alaska, 2004," Table 25 (2005).

The sustainability of the Alaska pollock fishery thus rests on the continued productivity of the large eastern Bering Sea pollock "stock," which has a patchy but continuous distribution across the shelf and slope waters from Unimak Pass in the southeast to Cape Navarin, Russia in the northwest. The modern fishery has relied on single large year classes[5] to sustain steady yields averaging about 1.2 million tons per year (t/yr) in the U.S. EEZ, while approximately another 500,000 t/yr have been taken, on average, from the Navarin Basin since 1980. In the late 1990s, as the strong 1989 and 1992 year classes dwindled in size and no new recruitment appeared, the stock was assessed at only 30% of its unfished equilibrium stock size and the risk of a crash was very real. Fortunately for fishery managers and the pollock industry, the 1996 year class was unexpectedly robust (there was great concern at the time about the effect of the Navarin fishery on this year class) and bolstered the fishery at the turn of the 21st century. Today, the 2000 year class is the main cohort supplying the fishery, but subsequent recruitment is believed to be poor and the present stock assessment anticipates continuing stock decline in 2006 and beyond.[6]

Notwithstanding record-high domestic yields of 1.4–1.5 million t/yr since 2001, claims that the eastern Bering Sea pollock fishery is sustainable must be viewed with great skepticism even within a conventional single-species framework. The NPFMC credits itself for the present high pollock yields in the eastern Bering Sea, citing conservative "harvest rates"— and, indeed, the catch limits applied to pollock in the eastern Bering Sea are more conservative than most, but it would seem to be a matter of luck that the eastern Bering Sea pollock stock has enjoyed favorable recruitment during a period when the Gulf of Alaska, Bogoslof/Aleutian Basin, and Aleutian Islands stocks sharply declined under the same management strategy and continue to show low productivity and poor recruitment.[7] Had the 1996 year class in the Bering Sea not appeared to save the day, the largest fishery in the United States might now be collapsing, and we would be writing postmortems on the Bering Sea pollock fishery similar to those that have been written for the Newfoundland and Georges Bank cod fisheries. Moreover, if the 2000 year class proves to be less robust than estimated in the most recent stock assessment, the pollock fishery could soon find itself on the brink of collapse once again.

NOTES

FACTORY FISHING ON THE LAST FRONTIER

[1] Since the late 1950s, when the first factory fishing ships of the distant water nations appeared off the coast of Alaska, approximately 74 million metric tons (163 billion pounds) of walleye pollock, Pacific cod, yellowfin sole, rock sole, Greenland turbot, rockfish, and other species have been reported as catch in the eastern Bering Sea, west-central Gulf of Alaska, and Aleutian Islands, not including incidental bycatch of non-target species before 1990. The total does not include catches of halibut, salmon, herring, crab, or shrimp, which are managed separately.

[2] One metric ton = 2204.62 pounds.

[3] Committee on the Bering Sea Ecosystem, NRC, *The Bering Sea Ecosystem* (Washington, DC: National Academy Press, 1996), 212-213.

[4] S. Allen Macklin, ed., *Bering Sea FOCI 1991-1997, Final Report*, NOAA ERL Special Report (Seattle, Washington: Pacific Marine Environmental Laboratory, 1998), 46.

[5] A year class is a cohort of fish that are all spawned in any given year.

[6] James N. Ianelli. Steve Barbeaux, and Gary Walters, et al., "Eastern Bering Sea Walleye Pollock Stock Assessment," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions*, comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (Anchorage, Alaska: NPFMC, 2004).

[7] Although uncertain, it is possible that periodic "spillover" from superabundant year classes on the eastern Bering Sea shelf is needed to replenish areas such as the Aleutian Basin and Aleutian Islands, in which case the Bering Sea pollock fishery may be removing fish that would otherwise migrate into outlying areas. However, pollock stock structure and relationships among designated "stocks" are highly uncertain throughout the North Pacific.

Bottom trawler *Defender* (Rockland, Maine) leaves harbor at St. Paul Island
© 2006 Todd Warshaw/Greenpeace USA.

IMPROVING UPON THE ALASKA APPROACH

Fishing is the catching of aquatic wildlife, the equivalent of hunting bison, deer and rabbits on land. Thus, it is not surprising that industrial-scale fishing should generally not be sustainable: industrial-scale hunting, on land, would not be, either.[1]

In the current debate over amending and reauthorizing the Magnuson-Stevens Act, advocates of enforceable catch limits to prevent overfishing in U.S. fisheries have portrayed the Alaska fisheries as models of good management. A recent editorial in the *Anchorage Daily News* urging Congress to embrace Alaska's "common sense" approach to overfishing is typical in this regard:

> *It seems pretty basic: When the feds set commercial fishing limits, you'd think rule No. 1 would be that you don't allow overfishing. You figure out how many fish can be caught every year without starting to shrink the species over the long term, and you don't let the fishing industry catch more than that. It's just common sense.*[2]

Since the NPFMC's system of control rules and catch limits was a model for the MSA's National Standard 1 guidelines on overfishing, it is important to understand what the Alaska model is, and is not.[3]

OVERFISHING: MSY AS YARDSTICK

In the amended Magnuson-Stevens Act, the terms "overfishing" and "overfished" are defined as a rate or level of fishing mortality that jeopardizes the ability of an exploited fish stock (or group of species treated as a "stock" for management purposes) to produce the maximum sustainable yield on a continuing basis.

In the simplest terms, MSY is the largest catch that the stock can sustain, on average, over a long period of time, given current ecological and environmental conditions. It sounds like a straightforward concept, but the Magnuson-Stevens Act's own national standard guidelines on overfishing cautioned that MSY is a theoretical concept rather than an empirical one.

That cautionary note has been lost in the debate about enforceable catch limits and Alaska's approach to overfishing. Measuring fishery sustainability by the theoretical yardstick of MSY is fraught with uncertainty, and the approach ignores the ecosystem.

ALASKA'S APPROACH TO OVERFISHING

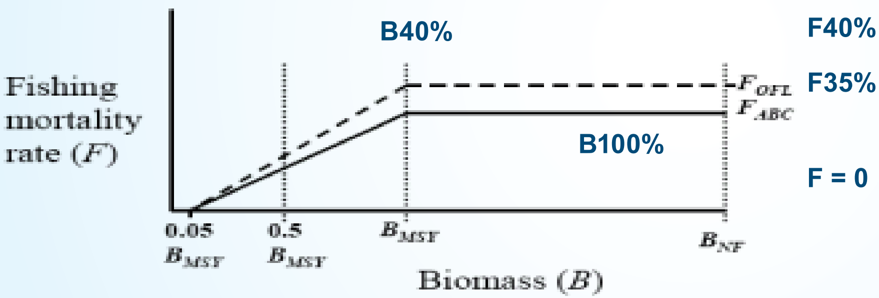
The Alaska approach to overfishing employs a system of enforceable catch limits, or quotas, based on criteria for achieving maximum sustainable yield (MSY) from individual species or groups of species in each fishery management plan. Such an approach uses fishing mortality control rules that are configured so that acceptable biological catch (ABC) is less than the overfishing level (OFL), and the total allowable catch (TAC) may not exceed ABC: TAC $\leq$ ABC < OFL.[4] This approach of setting ABC below the theoretical OFL and setting TAC no higher than ABC is an improvement over regions where catch limits do not exist or are simply ignored by fishermen. Further, a linear reduction in the fishery mortality ($F_{40\%)}$ rate that is applied whenever a stock is estimated to fall below its target biomass ($B_{40\%}$) is intended as a margin of safety at lower stock sizes (see Figure 6).

Photo: Freshly caught Alaska pollock © 2006 National Marine Fisheries Service/Alaska Fisheries Science Center.

FIGURE 6. FRAMEWORK FOR ACCEPTABLE BIOLOGICAL CATCH AND OVERFISHING LEVEL IN THE NORTH PACIFIC GROUNDFISH FISHERIES

1. Set "overfishing level" (OFL) at MSY or proxy
2. Calculate the fishing mortality rate (F) at OFL (F_{OFL})
3. Calculate the maximum permissible ABC (<OFL)
4. Calculate the fishing mortality rate used to set the maximum permissible ABC (max F_{ABC}):

Downward adjustment in *F* below $B_{40\%}$ to as little as 5% of $B_{40\%}$:



In theory, the North Pacific overfishing criteria ordinarily allow fishing to continue indefinitely up to the point where there is almost no spawning stock biomass remaining, albeit at lower and lower levels in proportion to the dwindling stock size.

SOURCE: NMFS, *Endangered Species Act Section 7 Consultation—Biological Opinion and Incidental Take Statement* (2000), Fig. 6.5.

The objective of the $F_{40\%}$ "harvest policy" (considered a conservative proxy for F_{MSY}) is to reduce the spawning stock 60% on average, by design — and more than 60% half the time, since this "target" stock size ($B_{40\%}$) is only an average. This is slightly more conservative than the designated overfishing level ($F_{35\%}$), and the levels of fishing that will *in theory* achieve this objective are estimated with low confidence (50%) and bounded by wide uncertainty intervals.

The U.S. Commission on Ocean Policy recommended that all Regional Fishery Management Councils (RFMCs) should be required to set "harvest" limits at or below an ABC value approved by the councils' Scientific and Statistical Committees (SSCs), as the NPFMC does.[5,6]

Catch limits establish a bright line, defining the scope of opportunity as well as the limits of the resource. But catch limits by themselves are no panacea — following scientific advice on fishing mortality limits is just the beginning. Once fishery managers set a catch limit, they must be able to enforce it, which means they also need reliable measures of catch, including incidental bycatch of non-target species. Effective quota-based management is information intensive and expensive.

The NPFMC is not called "the Cadillac of regional fishery management councils" for nothing. The data-intensive system of control rules and annual stock assessments involves hundreds of government scientists, an extensive system of on-board fishery observers, species-specific catch measurement, fishery-independent resource surveys, and in-season monitoring and enforcement capabilities — all of which cost a great deal of money to maintain. Unfortunately, even North Pacific-style catch limits do not escape the difficulties of quantifying biological reference points corresponding to MSY for wild fish stocks.

CAVEATS AND CAUTIONARY TALES: "MANAGEMENT BY THE NUMBERS" IS NO GUARANTEE THAT OVERFISHING WILL NOT OCCUR

The use of fishing mortality control rules and catch limits (even limits lower than the maximum allowable under MSY criteria) does not guarantee that overfishing will not occur, in part because the true abundance of fish in the ocean is inherently uncertain. This uncertainty is compounded by modeling parameter errors in the stock assessment advice and other sources of uncertainty over which managers have no control, such as environmental variability and predator-prey dynamics in the food web. Calculating a level of fishing that corresponds to theoretical MSY for a given population of wild, free-ranging fish is neither simple nor straightforward.

> **In many respects, the job of stock assessment scientists is impossible:**
>
> ***[T]o estimate the numbers and biomass of each harvested species in the ocean even though they cannot be seen; to determine demographic parameters such as growth and mortality even though such are affected by unobservable and complex interactions between species and the environment; and to forecast catches and population responses ahead 1–10 or more years even though incoming recruitment is known to be highly variable and affected by environmental events that may not yet have occurred.***
>
> Pamela M. Mace et al., *Marine Fisheries Stock Assessment Improvement Plan: Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments* (Washington, DC: U.S. Department of Commerce, NOAA, NMFS, 2001).

Information requirements for quota-based management as practiced in the North Pacific are very high, but no amount of information can eliminate the uncertainties inherent in every aspect of fisheries management because fish cannot be counted like trees or tracked on their seasonal migrations like caribou:

- Conventional single-species stock assessments are chockfull of unverifiable assumptions and portray fish populations with cartoon-like simplicity.[7]
- Wild fish stocks are subject to multiple sources of influence on population, most of which are not directly observable.[8]
- A great deal of guesswork and inference from limited data is necessarily involved in the stock assessment advice on which ABC is based.[9]

Thus, the claim that Alaska groundfish catch levels are conservative should be viewed as hypothesis rather than fact. Although no Alaska pollock stock has been deemed "overfished" under the technical definition of the MSA, for example, the National Research Council recognized a decade ago that exploited pollock stocks have suffered major declines since the 1980s:[10]

> *According to fishery managers, pollock stocks in the Bering Sea, Aleutian Islands, and Gulf of Alaska have not been "overfished" in recent years. Nonetheless, several regions where pollock were once abundant (e.g., Shelikof Strait, the Bogoslof Island area, and the donut hole) have been heavily exploited, and the pollock stocks are now very low in those areas.*[11]

Fisheries science necessarily relies on incomplete and limited data of questionable reliability, makes unverifiable assumptions about hidden states of nature, and provides probabilistic advice with low levels of confidence and large error bounds.[12,13] Determining the point estimate of yield corresponding to the target fishing mortality rate is a procedure fraught with uncertainty even for stocks considered to have the best data and the most sophisticated fishery stock assessments, such as eastern Bering Sea pollock.[14]

The theoretical yardstick of MSY and overly simplistic assumptions of "state-of-the-art" stock assessments are fertile ground for mistakes. More attention must be given to the data requirements and uncertainties associated with estimating OFL and ABC in the stock assessments in a conventional single-species context, based on proxy biological reference points ($F_{35\%}$, $F_{40\%}$, and $B_{40\%}$) corresponding to theoretical F_{OFL}, F_{MSY}, and B_{MSY}. Given all of these uncertainties, the MSA must require a precautionary management approach.

UNCERTAINTY IN CATCH LIMITS NECESSITATES GREATER PRECAUTION

Single-species stock assessment models oversimplify population dynamics of wild, free-ranging fish and tell us nothing about the larger uncertainties associated with

- **climate variability,**
- **food web dynamics in the ecosystem,**
- **the impacts of fishing gear on the habitats of fish and other wildlife,**
- **the spatial and temporal effects of concentrated fishing in localized areas,**
- **the effects on hundreds of poorly understood non-target species taken as bycatch.**

Thus, much of the uncertainty and risk inherent in managing large fisheries is left out of the stock assessment calculation of acceptable biological catch.

For all these reasons, stock assessments and catch limits by themselves are no guarantee of avoiding overfishing or fostering recovery:

> ***[M]any stock assessments have been predicated on the assumption that survey estimates of abundance, age-specific metrics of commercial catch, and a broad sense of the geographical limits of a commercially harvested fish population are all that one really requires to understand and predict the effects of fishing on fish populations. Yet, for many fisheries, we seem unable to predict either the susceptibility of fish stocks to collapse or their ability to recover therefrom.***[15]

The failure of single species or stocks of fish to respond predictably to MSY-based exploitation strategies may be attributable to inadequate information, flawed assumptions about species responses to a regimen of fishing mortality, extrinsic factors such as climate variability, or all of the above. Uncertainties and risks must be fully recognized and accounted for in setting catch limits. A great deal more precaution must be exercised in setting catch limits, and in cases of uncertainty, managers should err on the side of protecting the ecosystem.

The collapse of the northern cod fishery of Canada serves as a reminder of the fallibility of claims of conservative single-species quota management. Canadian fisheries managers asserted to the very end that they were employing a conservative fishing rate of $F_{0.1}$ compared to other Atlantic cod stocks.[16] Yet retrospective analyses indicate that the stock size estimates were consistently overestimated in successive stock assessments, leading to much higher rates of fishing mortality in hindsight.[17] Similar errors in estimating stock size were likely responsible for the rapid collapse of Alaska's red king crab fishery in the late 1970s and early 1980s, which was the most lucrative fishery in the Bering Sea at the time.[18]

Canada's northern cod fishery and Alaska's crab fisheries offer cautionary lessons about the uncertainties and risks associated with modern fisheries science and management. Overconfidence in "management by the numbers" can blind managers to the risks they incur, and the damage occurs before the mistake is realized. This is a particular risk in the North Pacific, where MSY-based catch controls are the cornerstone of claims to conservative management of the gargantuan groundfish fisheries.[19]

NOTES

IMPROVING UPON THE ALASKA APPROACH

[1] Daniel Pauly, Villy Christensen, and Sylvie Guenette, et al., "Towards Sustainability in World Fisheries," *Nature* 418 (2002): 689-695.

[2] "Alaska's Example: Congress Should Embrace Our Approach to Prevent Overfishing," *Anchorage Daily News*, November 18, 2005.

[3] National Standard One: "Conservation and management measures shall prevent overfishing while achieving, on a continual basis, the optimum yield from each fishery for the United States fishing industry."

[4] TAC is the catch level that NMFS authorizes the fisheries to catch, and is based on the ABC level.

[5] U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century. Final Report* (Washington, DC: 2004), 503.

[6] Currently, the MSA requires only that every RFMC have an SSC. There is no requirement that councils heed their advice.

[7] Robert Francis, "Some Thoughts on Sustainability and Marine Conservation," *Fisheries* 27, no. 1 (2002): 18-21.

[8] Daniel E. Lane and Halldor P. Palsson, "Stock Rebuilding Strategies Under Uncertainty," in *Fisheries and Uncertainty: A Precautionary Approach to Resource Management*, eds. Daniel V. Gordon and Gordon R. Munro (Calgary: University of Calgary Press, 1996), 74.

[9] Pamela M. Mace, Norman W. Bartoo, and Anne B. Hollowed, et al., *Marine Fisheries Stock Assessment Improvement Plan: Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments* (Washington, DC: U.S. Department of Commerce, NOAA, NMFS, 2001), 24.

[10] Committee on the Bering Sea Ecosystem, NRC, *The Bering Sea Ecosystem* (Washington, DC: National Academy Press, 1996).

[11] Ibid., 212-213.

[12] Jon T. Schnute and Laura J. Richards, "Use and Abuse of Fishery Models," *Canadian Journal of Fisheries and Aquatic Sciences* 58 (2001): 10-17.

[13] Daniel Goodman, Marc Mangel, and Graeme Parks, et al., *Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Fishery Management Plans—Draft report* (Anchorage, Alaska: NPFMC, 2002).

[14] John C. Field, *A Review of the Theory, Application and Potential Ecological Consequences of $F_{40\%}$ Harvest Policies in the Northeast Pacific*, (Alaska Oceans Network: 2002), 49.

[15] Jeffrey A. Hutchings, "Numerical Assessment in the Front Seat, Ecology and Evolution in the Back Seat: Time to Change Drivers in Fisheries and Aquatic Sciences?" *Marine Ecology Progress Series* 208 (2000): 299-302.

[16] Daniel E. Lane and Halldor P. Palsson, "Stock Rebuilding Strategies Under Uncertainty," in *Fisheries and Uncertainty: A Precautionary Approach to Resource Management*, eds. Daniel V. Gordon and Gordon R. Munro (Calgary: University of Calgary Press, 1996), 74.

[17] Alan Christopher Finlayson, *Fishing For Truth, A Sociological Analysis of Northern Cod Stock Assessments from 1977-1990* (St. John's, NL: Institute of Social and Economic Research, Memorial University, 1994), 37.

[18] C. Braxton Dew and Robert A. McConnaughey, "Did Trawling on the Brood Stock Contribute to the Collapse of Alaska's King Crab?" *Ecological Applications* 15 (2005).

[19] NMFS, *Alaska Groundfish Fisheries Draft Programmatic Supplemental Environmental Impact Statements on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2001, 2004).

Factory trawler *Browns Point* fishing for pollock in the Bering Sea
© Greenpeace/Visser.

SHIFTING BASELINES AND MOVING TARGETS:

STOCK STATUS FOR ALASKA POLLOCK RELATIVE TO OVERFISHING CRITERIA

The 1996 amendments to the Magnuson-Stevens Act defined the terms "overfishing" and "overfished" as a rate or level, respectively, of fishing mortality that jeopardizes the ability of an exploited fish stock (or group of species treated as a "stock" for management purposes) to produce the maximum sustainable yield on a continuing basis. In the simplest terms, MSY is the largest catch which the stock can sustain, *on average*, over a long period of time, given current ecological and environmental conditions.[1]

The key reference levels for MSY are the rate of fishing mortality (F) that will theoretically yield MSY (F_{MSY}) and the spawning stock size, or biomass (B), that will theoretically produce MSY (B_{MSY}) if one has been fishing at F_{MSY} over a long period. The MSA's National Standard 1 (NS1) provides technical guidance regarding overfishing; it provides a "limit control rule" that is indexed to the quantity of spawning stock biomass corresponding to the rate of fishing mortality that will theoretically yield MSY, or F_{MSY}. It sounds like a straightforward concept, but in the final rule on National Standard Guidelines, NMFS cautions that MSY is very difficult to achieve for a variety of reasons, calling it "a theoretical concept rather than an empirical one."[2]

The level of information required to calculate MSY is lacking for most fish stocks.[3] Therefore, the NS1 guidelines proposed "proxy" MSY reference points for situations in which information is limited; this approach is said to be modeled on the North Pacific practice of using spawning-per-recruitment (SPR) ratios as proxies for target and limit biological reference points corresponding to unknown or uncertain MSY parameters.[4] These proxies for F_{MSY}

and B_{MSY} are based on ratios of spawning stock biomass per recruit ($B_{SPR\%}$, produced by a corresponding fishing mortality rate, $F_{SPR\%}$). The SPR ratios depend on the shape and nature of the spawner-recruit relationship and the degree of density-dependent compensation, which is expressed as a ratio of the existing population to the population's carrying capacity.[5]

The proxy for B_{MSY} is $B_{40\%}$: this is approximately 40% (range 36.8% to 50%) of the unfished or pre-exploitation stock size.[6,7] The management aims for the biomass to be at this level by fishing at $F_{40\%}$ over time.[8] In many regions management has used $F_{20\%}$ to $F_{30\%}$ to compute overfishing levels.[9] However, in the North Pacific, $F_{40\%}$ is used for most commercially important species as a buffer against the inherent uncertainty in the stock-recruitment relationship and to provide a margin of safety.[10]

THE NORTH PACIFIC TIER SYSTEM

The NPMFC uses a 6-tiered system of control rules and overfishing criteria. Each level reflects how much information is known for biological reference points corresponding to MSY (i.e., greater confidence in the density-dependent relationship of spawning stock size to recruitment means a lower tier):

Tier 1: Reliable estimates of biomass (B), B_{MSY}, and probability density function of F_{MSY}

Tier 2: Reliable B, B_{MSY}, F_{MSY}, $F_{35\%}$, $F_{40\%}$

Tier 3: Reliable B, $B_{40\%}$, $F_{35\%}$, $F_{40\%}$

Tier 4: Reliable B, $F_{35\%}$, $F_{40\%}$

Tier 5: Reliable B and natural mortality (M)

Tier 6: Reliable catch history data

"Reliable," in this sense, means that a value can be estimated with uncertainty from available data. The term should not be confused with the common usage of the word, because the reliability of any value in this system is associated with low confidence (e.g., 50%). Many consider the North Pacific's management of the pollock fisheries under this system to be exemplary. The $F_{40\%}$ harvest policy is the cornerstone of the claim that the North Pacific's management is conservative and sustainable.[11]

Eastern Bering Sea pollock is managed under Tier 1 criteria employing an F_{MSY} strategy. Gulf of Alaska pollock is managed under Tier 3, employing the $F_{40\%}$ strategy. Both Bogoslof/Aleutian Basin and Aleutian Islands pollock stocks have been managed under Tier 5 in recent years.

There are elements of conservatism in this strategy compared to many parts of the world. For example, the system of control rules on fishing rates is configured so that maximum acceptable biological catch (ABC) is always less than the overfishing level (OFL), and the total allowable catch (TAC) may not exceed ABC. Setting ABC below the theoretical OFL and setting TAC no higher than ABC is an improvement over standard practice in many regions, and the linear reduction in the $F_{40\%}$ rate applied whenever a stock is estimated to fall below its $B_{40\%}$ target stock size is intended as a margin of safety at lower stock sizes. The North Pacific's extensive (and expensive) infrastructure of data collection, scientific assessment, in-season monitoring, and enforcement is also essential to obtain the needed data for this information-intensive system and to ensure that fisheries do not exceed the allotted annual catch levels.

However, the lack of consistently precautionary management for pollock is difficult to understand. For example, the Gulf of Alaska pollock TAC has been set at 100% of ABC for several years, even though estimates of stock biomass have reached historically low levels, while the Bering Sea pollock TAC has been set at "only" 55–77% of ABC since 2001.[12]

TABLE 3. EASTERN BERING SEA (EBS) POLLOCK STOCK ASSESSMENT STATUS AND CATCH SPECIFICATION (METRIC TONS), 2003–2006

Year	Tier	Model age 3+ biomass (t)	Overfishing level (OFL)	Acceptable biological catch (ABC)	Total allowable catch (TAC)	Catch
2003	1a	11,100,000	3,530,000	2,330,000	1,491,760	1,490,095
2004	1a	11,000,000	2,740,000	2,560,000	1,492,000	1,480,021
2005	1a	8,410,000	2,100,000	1,960,000	1,478,500	1,483,096
2006	1a	8,230,000	2,090,000	1,930,000	1,485,000	n/a

SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

TABLE 4. GULF OF ALASKA POLLOCK STOCK ASSESSMENT STATUS AND CATCH SPECIFICATIONS (METRIC TONS), 2003–2006

Year	Tier	Model age 3+ biomass (t)	Overfishing level (OFL)	Acceptable biological catch (ABC)	Total allowable catch (TAC)	Catch
2003	3b	727,830	78,000	47,950	47,950	49,300
2004	3b	769,420	91,060	64,740	64,740	63,913
2005	3b	765,180	144,340	85,190	85,190	80,181
2006	3b	n/a	110,100	80,390	80,390	n/a

SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

The reason for setting TAC equal to ABC in the Gulf and less than ABC in the Bering Sea is explained in part by the 2 million ton optimum yield (OY) catch limit in the Bering Sea, adopted under Amendment 1 to the BS/AI FMP in 1981. At the time of Amendment 1, MSY for the entire Bering Sea groundfish complex was estimated at 1.8–2.4 million t/year, and the OY range was set at 85% of the MSY range, or 1.4–2.0 million t/yr. The Final EIS on the BS/AI FMP indicates that the rationale for the BS/AI 2 million metric ton OY "cap" had to do with a desire to "approximate the harvest levels that have been attained in the recent past,"[13] in order not to disrupt the participants in the fishery at that time. The 2 million ton OY catch limit constrains the pollock TAC, which must allow for TAC allocation in other fisheries, as well. In most years, the eastern Bering Sea pollock TAC comprises approximately 70–75% of the total BS/AI groundfish TAC.

The reasons for setting TAC equal to ABC in the Gulf are harder to understand, given the current depleted level of the stock and the uncertainties in stock structure. The most likely reason for the differing approaches in the Bering Sea and the Gulf of Alaska is that the Gulf pollock ABC is not large enough to provide for the Gulf pollock fleet and thus the maximum permissible level is allocated to the fishery; in the Bering Sea, the ABC recommendations of recent years (2001–2006) have been far above what is considered optimum economically, and in some years, above the 2 million ton OY cap.

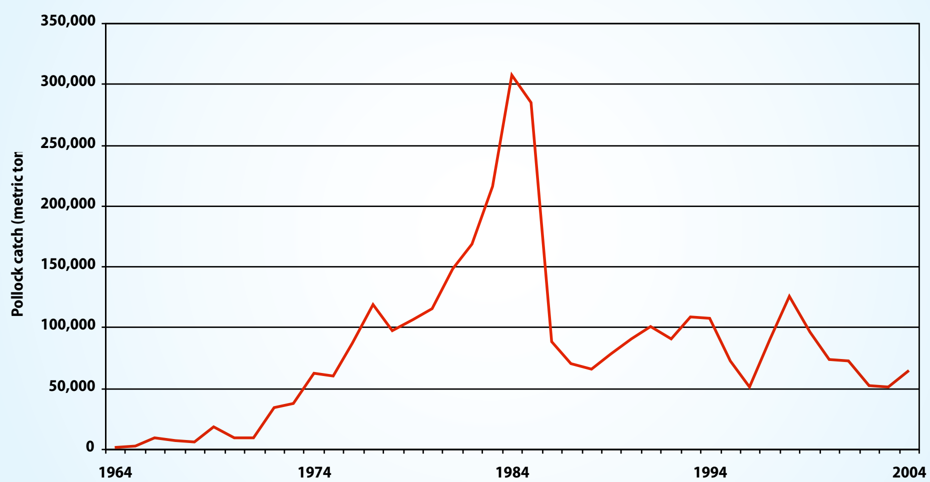
In the case of pollock, even the most basic level of information required for management (i.e., biomass estimation) is replete with uncertainty in all regions. The seasonal movements of pollock are not well understood due to limited seasonal and/or area survey information. Pollock stock structure and the degree of mixing among spawning aggregations remain largely unknown, further confounding efforts to assess productivity and infer stock-recruitment relationships for the currently defined "stocks." Their environment is characterized by high variability from year to year, and density-independent environmental forcing can have a profound influence on the survival of individual year classes to maturity. Basic information on pollock biology, stock structure, behavioral ecology, food web, preferred habitats, and seasonal movements must all be inferred from incomplete information, and the stock assessments rely on unverifiable assumptions about key biological parameters such as growth, maturity at age, fecundity, and natural mortality.

For all of these reasons, reliance on "the fishing mortality rate associated with 40% of the equilibrium level in the absence of fishing"[14] is not proof of precautionary management. Reliance on stock assessment advice and "conservative" single-species TAC-setting does not guarantee sustainability even in the single-species context. Overconfidence in "management by the numbers" without understanding the uncertainty associated with those numbers can blind managers to the real risks they incur, and the damage occurs before the mistake is realized. This is a particular risk in the North Pacific, where TAC-setting is the central management tool for achieving the goals of "target species management."[15]

GULF OF ALASKA POLLOCK

Currently, the Gulf of Alaska (GOA) pollock fishery is managed under the $F_{40\%}$ strategy in Tier 3 of the overfishing criteria. This strategy uses a slight downward adjustment in the fishing mortality rate per the criteria in Tier 3B to account for the fact that the Gulf pollock spawning stock is estimated to be below the $B_{40\%}$ "target" biomass level.

FIGURE 7. GULF OF ALASKA POLLOCK CATCH HISTORY, 1964–2004



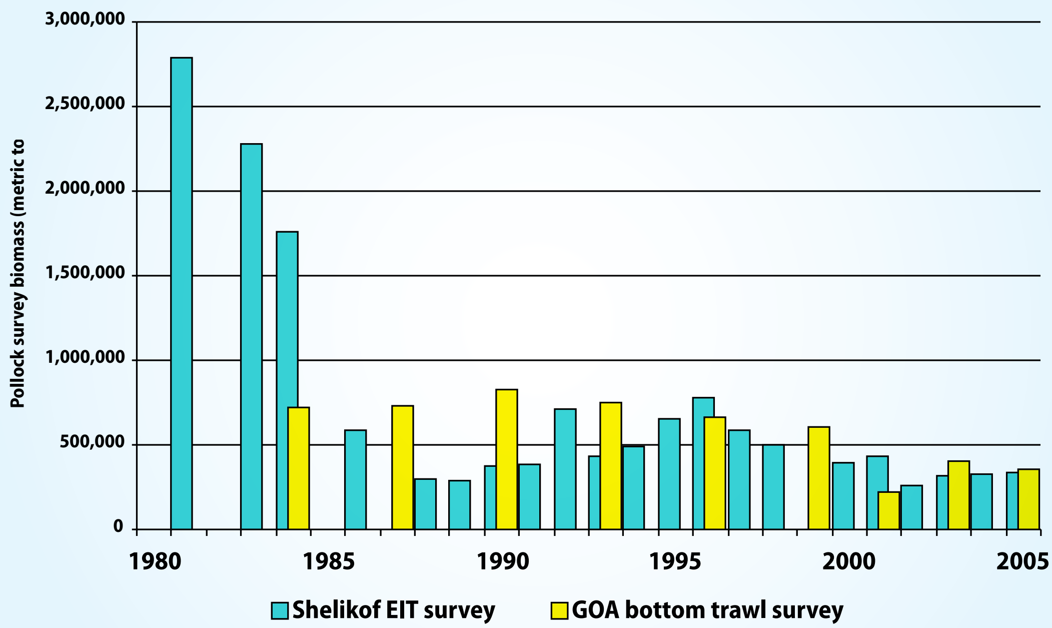
SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005). Table 1.1: 82.

GULF OF ALASKA POLLOCK ABUNDANCE TRENDS

The 2003 NMFS bottom trawl survey biomass estimate increased 86% over 2001. The 2004 Shelikof Strait Echo-Integration-Trawl (EIT)[16] survey biomass estimate increased 8% over the 2003 estimate, and the five-fold increase in Shelikof pollock of greater than 43 cm (a proxy for spawning biomass) was attributed primarily to the maturation of fish from the relatively strong 1999 year class. However, the Shelikof survey spawning biomass of pollock greater than 43 cm reached perilously low levels in 2001–2003, and the current spawning biomass is projected to peak in 2005 and decline in subsequent years, due to a lack of significant recruitment since 2000.[17]

Lack of recruitment after the 2000 year class and lower-than-expected spawning biomass estimates for the Shelikof Strait are concerns at present.[18] Low productivity has been a chronic condition of Gulf pollock since the collapse of the Shelikof Strait spawning stock in the 1980s, as shown in Figure 8.

FIGURE 8. SHELIKOF STRAIT WINTER EIT (ACOUSTIC) AND SUMMER BOTTOM TRAWL SURVEY TRENDS, 1981–2005.



SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska (2005).

Based on the time series of winter acoustic surveys at Shelikof Strait, Gulf of Alaska pollock abundance has declined by approximately an order of magnitude from its estimated stock size at the start of the Shelikof roe fishery in the early 1980s. Surprisingly, the stock assessment states that pollock is not technically in danger of becoming "overfished" because the model-estimated spawning-per-recruitment biological reference points for unfished stock size and the target stock size ($B_{40\%}$) are based on mean recruitment over the time series of recruitment and biomass, which is declining.

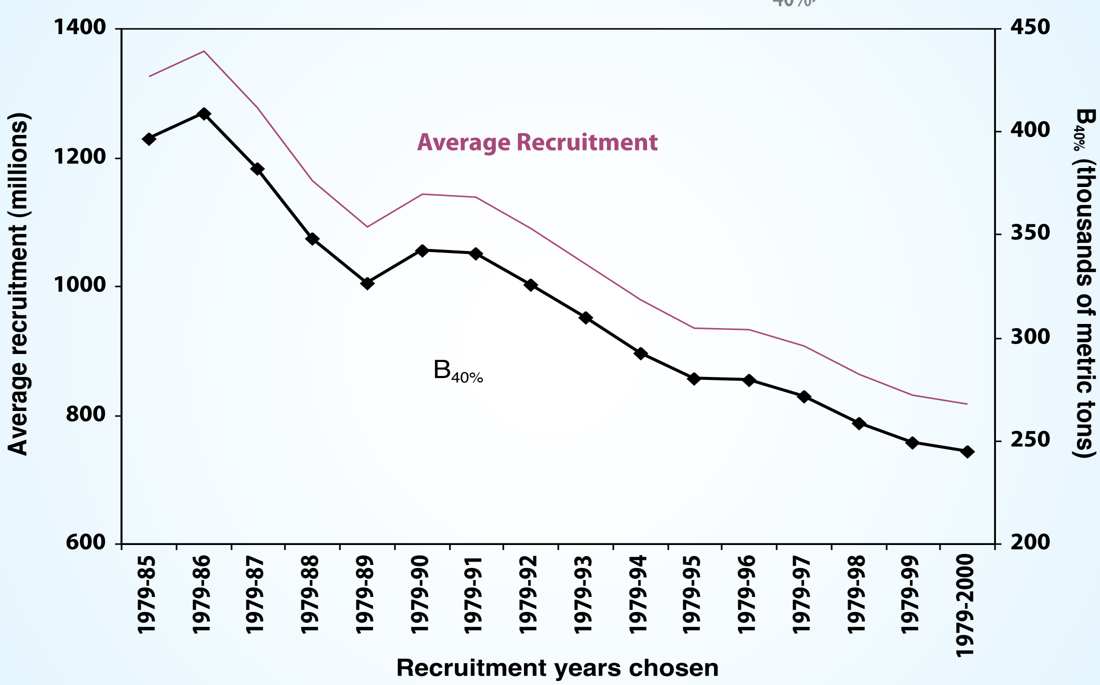
Thus, the model-projected 2005 $B_{40\%}$ estimate of 229,000 t was about 8% lower than the $B_{40\%}$ estimate of 248,000 t in the 2003 assessment, due to lower post-1977 mean recruitment and declining estimates of unfished spawning biomass at F = 0.[19] In short, the unfished stock size is a shifting baseline and $B_{40\%}$ is a moving target that continues to decrease as stock trends decline (see Table 5).

TABLE 5. GULF OF ALASKA BIOMASS REFERENCE LEVELS, 2001-2006			
Female spawning biomass reference levels	$B_{35\%}$	$B_{40\%}$	$B_{100\%}$
Stock assessment for 2001	218,000	250,000	624,000
Stock assessment for 2002	214,000	245,000	612,000
Stock assessment for 2003	210,000	240,000	600,000
Stock assessment for 2004	217,000	248,000	620,000
Stock assessment for 2005	200,000	229,000	573,000
Stock assessment for 2006	196,000	224,000	559,000

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2000-2005).

It is difficult for the stock to be declared "overfished" under a fishing strategy in which limit and target stock thresholds are fluctuating averages, rather than fixed quantities of fish biomass; the reference unfished stock size ($B_{100\%}$) and target stock size ($B_{40\%}$) are fixed proportions of an estimated stock size that is increasing and decreasing over time. The biological reference points corresponding to B_{MSY} or proxy $B_{SPR\%}$ are derived in the model by assuming average recruitment, which is a risk-neutral assumption, at best. The average changes with each new increment of abundance data, and the values corresponding to $B_{40\%}$ and $B_{100\%}$, increase or decrease proportionally. In a population with a long-term declining trend, such as Gulf pollock, the stock "biomass" corresponding to these reference points diminishes steadily, as shown in this plot of Gulf pollock recruitment and $B_{40\%}$ values for the years 1979–2000:

FIGURE 9. GULF OF ALASKA POLLOCK RECRUITMENT AND $B_{40\%}$, 1979–2000



SOURCE: NMML, NMFS

In theory, the North Pacific overfishing criteria would allow fishing to continue indefinitely up to the point where there is almost no spawning stock biomass remaining (5% of $B_{40\%}$, 2% of $B_{100\%}$), albeit at lower and lower levels in proportion to the dwindling stock size. Under the Steller sea lion Reasonable and Prudent Alternative (RPA) rules, $B_{20\%}$ was arbitrarily adopted as a cut-off point for pollock fishing to avoid reaching this nadir. In a declining stock such as Gulf pollock, however, the model estimates of stock biomass corresponding to $B_{20\%}$ (like all other reference points) decrease over time due to declining average recruitment — in effect, the stock biomass representing the "overfished" limit is a sliding baseline that will never be reached because it diminishes as the stock approaches the threshold.

According to the North Pacific overfishing criteria, Gulf pollock is considered "healthy," although greatly diminished in comparison to the stock biomass in the early years of the fishery. The risk is that the diminished state of this "fished-down" stock becomes the new, shifted baseline and reference level for a stock at carrying capacity. The high abundance of Gulf pollock in the early 1980s is dismissed as a rare recruitment event, and the subsequent decline is attributed not to overfishing but to unspecified "recruitment failure" and climate changes.

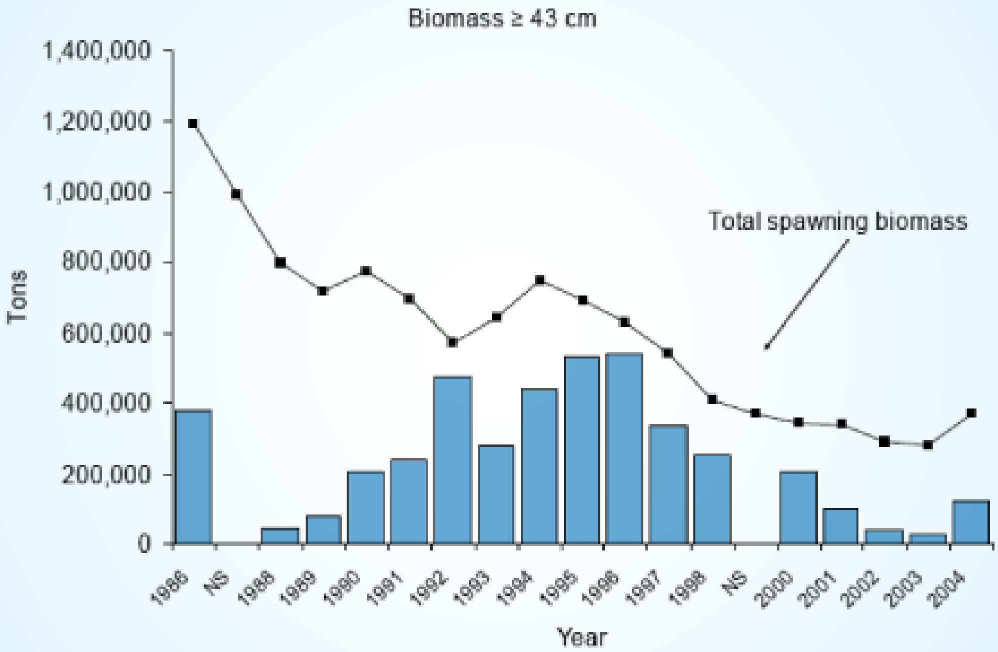
In other words, in the context of the North Pacific fisheries, the NPFMC and NMFS have all but defined "overfishing" and "overfished" out of existence.

Factory trawler *Ocean Rover* © Visser/Greenpeace

GULF OF ALASKA STOCK STATUS RELATIVE TO PROXY MSY REFERENCE LEVELS

Model estimates of current stock size have ranged from 26–37% of the equilibrium unfished spawning stock size (i.e., below $B_{40\%}$ target stock size) since 2002. Spawning biomass estimates for 1999–2004 (143,000–184,000 t) were the lowest since the start of the time series in 1969–1973 (143,000–192,000 t),[20] a period when pollock abundance is disputed. The estimated levels of pollock biomass of greater than 43 cm (a proxy for spawning biomass) in Shelikof winter acoustic surveys were small from 2002–2004 and the model-estimated spawning biomass indicates that spawning stock is lower today than at any time in recent history, as shown in Figure 10, which compares the Shelikof survey spawning biomass to the assessment model estimate of total spawning biomass.

FIGURE 10. SHELIKOF STRAIT POLLOCK BIOMASS ESTIMATES, 1986–2004



SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005), Figure 1.6, 67.

The age-structured population model estimate of spawning biomass for 2005 (168,000 t) was only 48.5% of the 1969–2004 average (346,000 t) and 37% of model-estimated unfished spawning biomass. Because this was below the $B_{40\%}$ value of 229,000 tons, Gulf pollock fell into sub-Tier 3b of Amendment 56 (see Table 6).

TABLE 6. MODEL REFERENCE POINTS AND PROJECTED 2005 GULF OF ALASKA POLLOCK SPAWNING STOCK BIOMASS

Female spawning biomass reference levels	Model results (metric tons)	Model 2005 spawning biomass
$B_{100\%}$	573,000	212,000 t (= $B_{37\%}$)
$B_{40\%}$	229,000	
$B_{35\%}$	200,000	

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

Model-projected start-of-year spawning biomass in 2006 is 193,092 t, which is 35% of model-estimated unfished spawning biomass (i.e., below the $B_{40\%}$ value of 224,000 t). Therefore, Gulf pollock falls into sub-Tier 3B of Amendment 56 (see Table 7).

TABLE 7. MODEL REFERENCE POINTS AND PROJECTED 2006 GULF OF ALASKA POLLOCK SPAWNING STOCK BIOMASS

Female spawning biomass reference levels	Model results (metric tons)	Model 2006 spawning biomass
$B_{100\%}$	559,000	193,092 t (= $B_{36\%}$)
$B_{40\%}$	224,000	
$B_{35\%}$	196,000	

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

2005–2006 ABC RECOMMENDATION FOR GULF OF ALASKA POLLOCK

Model estimates of current stock size relative to $B_{100\%}$ have ranged from $B_{26\%}$ in 2002 to $B_{35\%}$ in 2006 (i.e., below $B_{40\%}$ target stock size). Although the density-dependent assumption of the $F_{40\%}$ strategy would predict the production of strong year classes at this low spawning biomass level, recruitment has generally been weak for the past two decades.[21] If a strong year class appears, the fishery TAC levels are raised and the stock is rapidly fished down again. Thus, the continued recruitment from the 1999 year class and indications of increased abundance in the surveys result in a higher recommended ABC for 2005–2006 compared to 2003–2004 (see Tables 8 and 9).

TABLE 8. TIER 3B MAXIMUM PERMISSIBLE ABC AND OFL VALUES FOR 2005

Harvest strategy	$F_{SPR\%}$	Model 2005 projected yield
F_{ABC} (adjusted)	$F_{40\%}$	85,190 t
F_{OFL}	$F_{35\%}$	144,340 t

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

TABLE 9. TIER 3B MAXIMUM PERMISSIBLE ABC AND OFL VALUES FOR 2006

Harvest strategy	$F_{SPR\%}$	Model 2006 projected yield
F_{ABC} (adjusted)	$F_{40\%}$	81,300 t
F_{OFL}	$F_{35\%}$	110,000 t

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

Recent TAC recommendations for Gulf pollock have been set at 100% of the ABC value at $F_{40\%(adjusted)}$ as estimated in the stock assessment, despite the chronic low stock biomass and weak recruitment trends. Importantly, catch exceeded the maximum permissible ABC limit in 2003 (see Table 10).

TABLE 10. GULF OF ALASKA POLLOCK STOCK ASSESSMENT STATUS AND CATCH SPECIFICATIONS (METRIC TONS), 2003–2006					
Year	Model age 3+ biomass (t)	Overfishing level (OFL)	Acceptable biological catch (ABC)	Total allowable catch (TAC)	Catch
2003	727,830	78,000	47,950	47,950	49,300
2004	769,420	91,060	64,740	64,740	63,913
2005	765,180	144,340	85,190	85,190	80,181
2006	n/a	110,100	80,390	80,390	n/a

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2004,5).

It is difficult to understand how setting the TAC at 100% of ABC is conservative or risk averse given the poor recruitment and low abundance of this stock.

The assessment authors proposed a more conservative approach to ABC-setting in 2005, based on the choice of an $F_{50\%}$ strategy "to dampen yield variability and lessen short-term stock decline."[22] The more conservative $F_{50\%}$ strategy would have produced an ABC of 79,980 t in 2005 — a modest adjustment to the conventional $F_{40\%}$ approach under Tier 3 rules, but a significant departure from usual procedure. The Gulf of Alaska stock assessment Plan Team agreed with the stock assessment authors' concerns about the status of stock but ultimately rejected the proposed $F_{50\%}$ strategy:

> *The Plan Team agrees with the authors' concerns about the apparent lack of strong recruitment since the 2000 year class, the lower than expected spawning biomass estimates for Shelikof Strait, and the projected decline in biomass after 2005. However, the Plan Team disagreed on the appropriate response to capture these concerns and uncertainty. The authors recommended a temporary change to an a $F_{50\%}$ harvest rate in 2005 and 2006 to stabilize yields over the short-term, reduce the rate of biomass decline, and . . . address any residual concerns about the strength of the 1999 year class. While the Plan Team supported these motivating factors, they disagreed on the selection of an appropriate SPR rate, i.e., the selection of $F_{50\%}$ and the time frame under which to apply this rate.*[23]

The Gulf of Alaska Plan Team's unwillingness to support the stock assessment authors' recommendation for a lower $F_{50\%}$ fishing mortality rate in 2005 reflects institutional reluctance to depart from established overfishing criteria and rules. The case for an alternative, more conservative fishing strategy is compelling in a single-species context, and the consideration of major Gulf pollock predators such as the Steller sea lion only makes the case stronger. The charge of the scientific advisors who comprise the North Pacific groundfish Plan Teams is to set ABCs based on the conventional single-species criteria, however, and the system provides no incentive to consider more conservative alternatives.

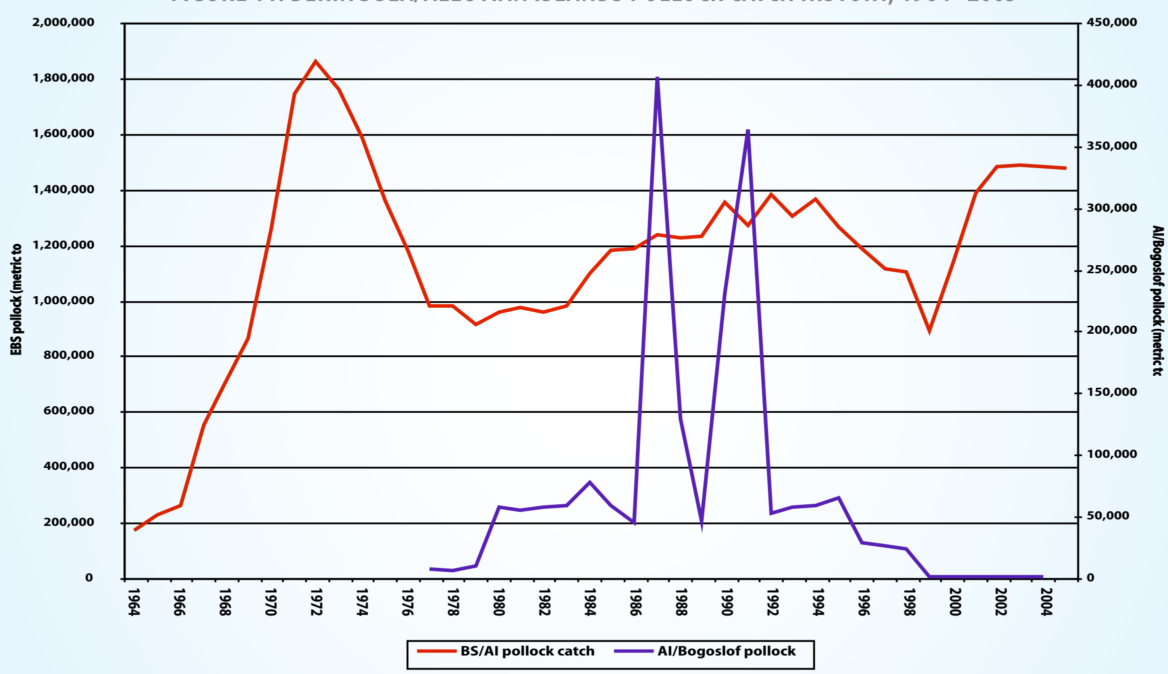
EASTERN BERING SEA POLLOCK

Eastern Bering Sea (EBS) pollock was managed under an $F_{40\%}$ strategy in the 1990s but is now managed under Tier 1 of the overfishing criteria. EBS pollock is the only stock currently deemed to have enough information to merit Tier 1 status, in which reference points corresponding to F_{MSY} and B_{MSY} are considered to be "reliably" estimated. However, EBS pollock has only occupied Tier 1 status for a few years and the assessment authors question the reliability of these estimates and continue to express their ambivalence about the use of Tier 1 values:

> *Estimates of reference points related to maximum sustainable yield (MSY) are currently available. However, the extent of their reliability is questionable. We therefore present both reference points for pollock in the BSAI to retain the option for classification in either Tier 1 or Tier 3 of Amendment 56.*[24]

In 2004, the assessment authors recommended using the marginally lower (i.e., more conservative) $F_{40\%}$ value to set ABC in 2005.

FIGURE 11. BERING SEA/ALEUTIAN ISLANDS POLLOCK CATCH HISTORY, 1964–2005



SOURCE: The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (2005).

TABLE 11. 2004 ALLOCATIONS OF THE BERING SEA POLLOCK TAC (METRIC TONS) AND DIRECTED FISHING ALLOWANCE (DFA) TO THE INSHORE, OFFSHORE, MOTHERSHIP, AND CDQ SECTORS

Area & sector	2004 allocations	A season		B season
		40% of annual TAC	SCA harvest limit (up to 70%)[25]	60% of annual TAC
CDQ reserve	149,200	59,680	41,776	89,520
Incidental catch allowance	43,641	n/a	n/a	n/a
AFA inshore	649,580	259,832	181,882	389,748
AFA offshore	519,664	207,865	145,506	311,798
AFA motherships	129,916	51,966	36,376	77,950
Total Bering Sea DFA	1,492,000	579,343	405,540	869,016

SOURCE: NMFS Alaska Region, <www.fakr.noaa.gov>.

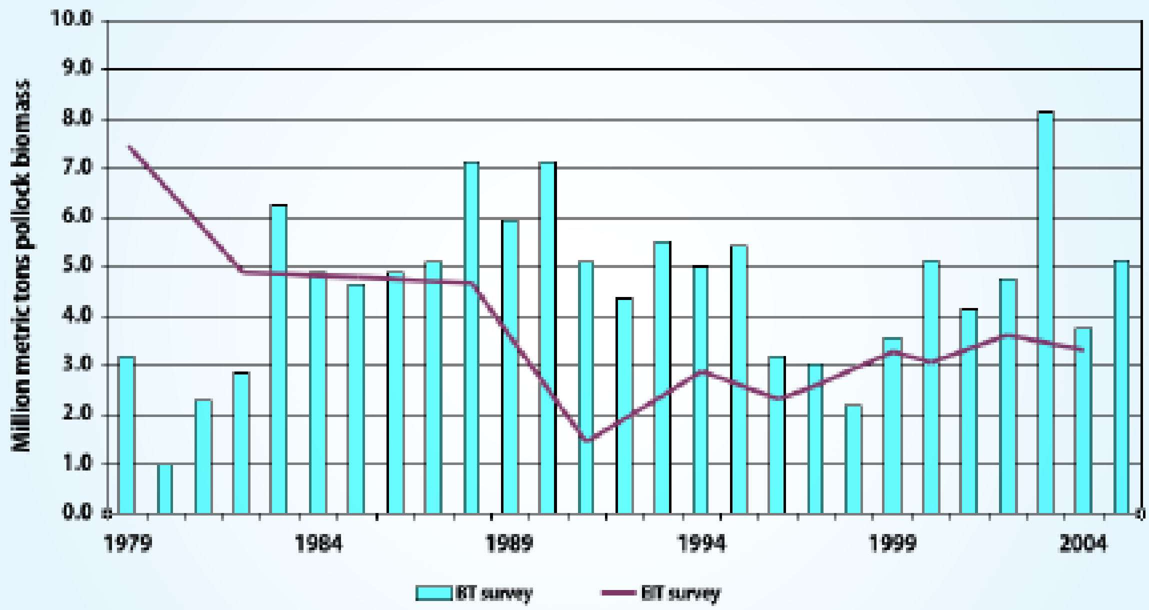
Some Plan Team members question the usefulness of MSY-based reference points, based on consideration of the possible effects that environmental regime shifts may have on the long-term productivity of the stock.[26,27] In other words, if the proponents of climate regime shift theory are correct, the current dominance of pollock in the eastern Bering Sea could be greatly reduced or even overturned by regularly occurring decadal-scale shifts of the climate.

The fact that pollock productivity and abundance have been low in other parts of the Bering Sea and Gulf of Alaska is not consistent with the regime shift hypothesis, but the question underscores the uncertainty associated with our knowledge of long-term pollock trends due to lack of historical baseline information on pollock abundance going back to the 1970s.[28]

EASTERN BERING SEA POLLOCK ABUNDANCE TRENDS

The 2004 summer bottom trawl survey estimated a pollock biomass of 3.75 million tons, *a decrease of 54% relative to an all-time high estimate of over 8 million tons in 2003*.[29] The 2004 summer EIT survey estimated a biomass of 3.31 million tons, a decrease of 8% relative to the 2002 EIT estimate. The 2005 bottom trawl survey estimated a pollock biomass of 5.13, an increase of 37% over the 2004 survey estimate.[30] Survey abundance trends over the entire time series are shown below in Figure 12.

FIGURE 12. POLLOCK BIOMASS TRENDS (AGE 1+) IN EASTERN BERING SEA GROUNDFISH SURVEYS, 1979–2004



SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

The one-year decline of 54% from the 2003 to 2004 groundfish bottom trawl surveys (a key fishery-independent index to which the stock assessment model is "fitted" or "tuned") underscores the uncertainty associated with abundance estimation in the surveys. In the case of the bottom trawl survey, the trawl catch per unit effort (CPUE) data from all survey stations are averaged and extrapolated to the survey area of the Bering Sea to provide a stock-wide biomass estimate, an inherently uncertain procedure. The patchy distribution of pollock results in high survey error bounds, called the coefficient of variation (CV), compared to more uniformly distributed species (e.g., some flatfish species), and annual changes in the ocean-bottom temperatures can have a strong effect on pollock distribution and survey CPUEs. The uncertainty in the abundance estimate from the survey is not explicitly factored into the stock assessment ABC recommendation.

Stock assessment authors Ianelli et al. noted that the 2000 year class appears to be above average and is the main age group available to the fishery.[31] However, the assessment authors also noted that the 2001, 2002, and 2003 year classes are thought to be well below average. Stock levels for EBS pollock appear to be lower overall than estimated in 2003 and the model-projected 2005 exploitable biomass (8.41 million t) was the lowest estimated since 1992.[32] For 2006, exploitable biomass is projected at 8.23 million t, slightly lower than the 2005 model estimate. Significantly, the 2000 year class is estimated to comprise 42% of the exploitable biomass.[33]

The EBS pollock fishery continues to be recruitment driven and dependent on the appearance of single, large year classes to restock the spawning biomass. For much of the 1990s, the pollock fishery was supported by one large 1989 year class and a lesser 1992 year class. By 1998, as these year classes were fished out of the population, the 1.1 million t ABC/TAC was equal to 50% of the estimated 1998 spawning biomass of 2.2 million t in the assessment model of the time,[34] and the BS/AI Plan Team estimated that EBS pollock spawning biomass was at only 30% of its unfished "equilibrium" biomass. Luckily, the 1996 year class proved robust, replenished the spawning stock, and sustained the fishery at the turn of the century.

Today, the fishery is relying on fish from a relatively strong 2000 year class, but the true size of any year class is unknown until it has been fished out of the population. Given the reliance on single cohorts of fish whose true abundance is unknown, it is inherently risky to raise TACs to the record-high levels of nearly 1.5 million t in recent years. Repeated targeting of a few strong year classes without subsequent strong recruitment is believed to be responsible for the sudden demise of the central Bering Sea/Aleutian Basin pollock fishery of the late 1980s.

EASTERN BERING SEA STOCK STATUS RELATIVE TO MSY REFERENCE LEVELS

The EBS pollock assessment model estimated a 2005 B_{MSY} value of 2.23 million t (down from 2.47 million t in 2004) and projected a 2005 female spawning biomass of 2.87 million t (at an $F_{40\%}$ rate) or 2.706 million t (at an F_{MSY} rate), either of which is above the corresponding "target" biomass level ($B_{40\%}$, B_{MSY}) placing EBS pollock in Tier 1a:

TABLE 12. MODEL REFERENCE LEVEL PROJECTIONS FOR EASTERN BERING SEA POLLOCK IN 2005

Female spawning biomass reference levels (Tier 1)	Model results	Model 2005 spawning biomass
$B_{100\%}$	7,232,000 t	2,871,000 t[1] (= $B_{40\%}$ or 108% of $B_{40\%}$)
B_{MSY}	2,226,000 t	
$B_{40\%}$	2,645,000 t	2,706,000 t[2] (= $B_{34\%}$ or 121% of B_{MSY})
$B_{35\%}$	2,314,000 t	

SOURCE: James Ianelli et al., "Eastern Bering Sea Walleye Pollock Stock Assessment," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004).

[1] At time of spawning, fishing at $F_{40\%}$

[2] At time of spawning, fishing at F_{MSY}

The current EBS pollock assessment model projects a 2006 B_{MSY} value of 2.122 million t (down from 2.226 million t in 2005), $B_{40\%}$ value of 2.595 million t (down from 2.645 million t in 2005), and a 2006 female spawning biomass of 2.677 million t (at an $F_{40\%}$ rate) or 2.503 million t (at an F_{MSY} rate), either of which is above the corresponding "target" biomass level ($B_{40\%}$, B_{MSY}), placing EBS pollock in Tier 1a/3a (see Table 13).

TABLE 13. MODEL REFERENCE LEVEL PROJECTIONS FOR EASTERN BERING SEA POLLOCK IN 2006

Female spawning biomass reference levels (Tier 1 & 3)	Model results	Model 2006 spawning biomass
$B_{100\%}$	6,563,000 t	2,677,000 t (= $B_{41\%}$)
B_{MSY}	2,122,000 t	
$B_{40\%}$	2,625,000 t	2,503,000 t (=118% of B_{MSY})
$B_{35\%}$	2,297,000 t	

SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005). Tables 1.17 and 1.29.

[1] At time of spawning, fishing at $F_{40\%}$

[2] At time of spawning, fishing at F_{MSY}

As it stands, there are two theoretical values corresponding to two different fishing rates at the beginning of the spawning season. But the actual F rate corresponding to the recommended 2006 TAC level is said to be approximately $F_{48\%}$.[35]

2005–2006 ABC RECOMMENDATIONS FOR EASTERN BERING SEA POLLOCK

For EBS pollock, the maximum permissible ABC is derived by computing the ratio between the estimated MSY and the equilibrium age 3+ biomass corresponding to MSY. Using this formula, the maximum acceptable biological catch (maxABC) for 2005 was 1.96 million t, which was approximately 3% higher than the 2005 yield corresponding to an $F_{40\%}$ strategy (1.897 million t) (see Table 14).

TABLE 14. TIER 1a MAXIMUM PERMISSIBLE ABC AND OFL VALUES FOR 2005

Harvest strategy	F_{MSY} / $F_{SPR\%}$	Model 2005 projected yield
F_{ABC}	F_{MSY} (harmonic mean)	1,962,000 t
B_{MSY}	F_{MSY} (arithmetic mean)	2,104,000 t
$B_{40\%}$	$F_{40\%}$	1,897,000 t

SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

For 2005, the assessment authors recommended setting ABC at the lower $F_{40\%}$ level, which reflects a continued ambivalence about the reliability of Tier 1 MSY estimates for this stock and the projected declines in recruitment in future years.[36] The Bering Sea/Aleutian Islands Plan Team agreed with the assessment authors' concerns about future recruitment trends but rejected the proposed use of $F_{40\%}$ rather than F_{MSY} to set ABC:

> *…[T]he Plan Team does not find any compelling reason to depart from the approach used to recommend ABC for the last three years, and so recommends setting the 2005 ABC at the maximum permissible level of 1,960,000 t. At the same time, the Plan Team notes that the 2001, 2002, and 2003 year classes are all estimated to be well below average*

and that the ABC recommendations for the near future are expected to be substantially lower than the 2005 recommendation.[37]

For 2006, the 2000 year class is estimated to comprise nearly half of the exploitable biomass, stock biomass estimates are marginally lower, and future stock declines are anticipated:

The 2000 year class is well above average and represents the mainstay of the population (about 27% of the total biomass in 2006, or 42% of the "exploitable" biomass). Projections based on the current age-composition estimates indicate that the spawning stock is likely to drop below the $B_{35\%}$ level by 2007 and may drop below B_{MSY} by 2008. Choosing a harvest level that reduces this likelihood could 1) provide stability to the fishery; 2) provide added conservation given the current Steller sea lion population declines; and 3) provide added conservation due to unknown stock removals in Russian waters. Therefore it seems prudent to recommend harvest levels below the maximum permissible values (e.g., constant catch scenarios of 1.5 and 1.3 million t . . .).[38]

TABLE 15. TIER 1a MAXIMUM PERMISSIBLE ABC AND OFL VALUES FOR 2006

Harvest Strategy	F_{MSY} / $F_{SPR\%}$	Model 2006 projected yield
F_{ABC}	F_{MSY} (harmonic mean)	1,931,000 t
F_{OFL}	F_{MSY} (arithmetic mean)	2,085,000 t
F_{ABC}	$F_{40\%}$	1,876,000 t

SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

In reality, EBS pollock allowable catch levels have been set below the ABC value since the stock was elevated to Tier 1. In 2003, for instance, the TAC of 1.471 million t was set at 64% of the ABC value, in 2004 the TAC of 1.492 million t was set at 58% of the ABC value, and in 2005 the TAC of 1.478 t was set at 75% of the ABC value. The Council-recommended 2006 TAC (1,485,000 t) is 77% of the maximum permissible ABC value (see Table 16).

TABLE 16. EASTERN BERING SEA POLLOCK STOCK ASSESSMENT STATUS AND CATCH SPECIFICATIONS (METRIC TONS), 2003–2006

Year	Model age 3+ biomass	Overfishing level (OFL)	Acceptable biological catch (ABC)	Total allowable catch (TAC)	Catch
2003	11,100,000	3,530,000	2,330,000	1,491,760	1,490,095
2004	11,000,000	2,740,000	2,560,000	1,492,000	1,480,021
2005	8,410,000	2,100,000	1,960,000	1,478,500	1,483,096
2006	8,230,000	2,090,000	1,930,000	1,485,000	n/a

SOURCES: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005); "Eastern Bering Sea Walleye Pollock Stock Assessment," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2002-4).

A time series of ABC, TAC, and catch levels since 1977 shows that TAC was set at 100% of ABC from 1994-2000, and over the period 1977-2000, TAC levels averaged 91% of ABC. Starting in 2001, however, ABC estimates rose to record levels and although TAC levels were also raised to record levels for the domestic fishery, TAC has averaged only 66% of ABC since 2001 (see Table 17).

TABLE 17. TIME SERIES OF ABC, TAC, AND CATCH FOR EASTERN BERING SEA POLLOCK, 1977–2004

	Year	ABC	TAC	TAC % ABC	Catch
	1977	950,000	950,000	100%	978,370
	1978	950,000	950,000	100%	979,431
	1979	1,100,000	950,000	86%	935714
	1980	1,300,000	1,000,000	77%	958,280
	1981	1,300,000	1,000,000	77%	973,502
	1982	1,300,000	1,000,000	77%	955,964
	1983	1,300,000	1,000,000	77%	981,450
	1984	1,300,000	1,200,000	92%	1,092,055
	1985	1,300,000	1,200,000	92%	1,139,676
	1986	1,300,000	1,200,000	92%	1,141,993
	1987	1,300,000	1,200,000	92%	1,018,946
	1988	1,500,000	1,300,000	87%	1,228,721
	1989	1,340,000	1,340,000	100%	1,229,600
	1990	1,450,000	1,280,000	88%	1,455,193
	1991	1,676,000	1,300,000	78%	1,093,670
	1992	1,490,000	1,300,000	87%	1,301,137
	1993	1,340,000	1,300,000	97%	1,306,263
	1994	1,330,000	1,330,000	100%	1,282,379
	1995	1,250,000	1,250,000	100%	1,182,388
	1996	1,190,000	1,190,000	100%	1,126,049
	1997	1,130,000	1,130,000	100%	1,059,061
	1998	1,110,000	1,110,000	100%	1,021,775
	1999	992,000	992,000	100%	987,492
	2000	1,139,000	1,139,000	100%	1,117,672
	2001	1,842,000	1,400,000	76%	1,244,956
	2002	2,110,000	1,485,000	70%	1,400,603
	2003	2,330,000	1,491,760	64%	1,491,760
	2004	2,560,000	1,492,000	58%	1,480,830
1977–2004	average	1,399,250	1,195,706	85%	1,149,146
1977–2000	average	1,264,042	1,150,458	91%	1,106,116
2001–2004	average	2,210,500	1,467,190	66%	1,404,537

SOURCE: James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

On paper, the recent TAC levels appear to be below the theoretical overfishing level and below the maximum permissible ABC level for Tier 1 (i.e., F_{MSY}), and therefore "conservative" in a single-species context. However, these computer generated numbers need to be placed in perspective:

1) The high point estimates of OFL and ABC values in recent years result from stock assessment assumptions and are selected from the *midpoint* of F_{MSY} yield as estimated by the model, i.e., at the 50% confidence level. Thus the estimates of yield at F_{OFL}, F_{MSY}, and $F_{40\%}$ have a low probability

of being correct within the assumptions of the model and large error bounds. In short, yield is estimated with a high degree of uncertainty. The tendency to talk about OFL/ABC numbers as if they are without error is a dangerous habit that leads managers to assume that TAC levels are safely below overfishing thresholds.

2) The EBS pollock ABC and TAC levels of recent years are the highest in the history of the domestic fishery and exceed the maximum permissible ABC recommendations of recent historical stock assessments (prior to 2001), even though the estimated stock biomass is not appreciably higher today than at other times in the past. In other words, changes in the assumptions of the stock assessment model have produced higher ABC values since 2001 even though the estimated abundance of Bering Sea pollock has not increased correspondingly during this time but has fluctuated within the range of stock sizes estimated since the 1980s.

3) Although NMFS does not say so explicitly, the EBS pollock stock is managed under a more or less constant catch policy because socioeconomic considerations are weighed equally against other considerations. Regardless of the ABC recommendation in any given year, under U.S. management, TAC levels have ranged from 1–1.5 million t/yr since 1990 and have averaged approximately 1.25 million t/yr. The reasons for setting TAC within this range are partly explained by the 2 million t OY limit in the Bering Sea, but the TAC level is also calculated to provide an optimum level of economic benefit that ensures the industry participants an adequate supply of fish while maintaining stability.[39]

4) As long as there is no danger of catching the full amount of ABC (under the 2 million t OY limit), the higher ABC values make fishery and industry officials appear precautionary. It is highly doubtful that any fishery manager believes that the Bering Sea pollock stock could sustain a catch equal to the 2004 ABC value of 2.5 million t (the highest catch in the history of the fishery was 1.8 million t in 1972, and the stock was considered overfished by the mid-1970s), but inflated ABC values make the 2002–2005 catch of nearly 1.5 million t/yr appear conservative by comparison.

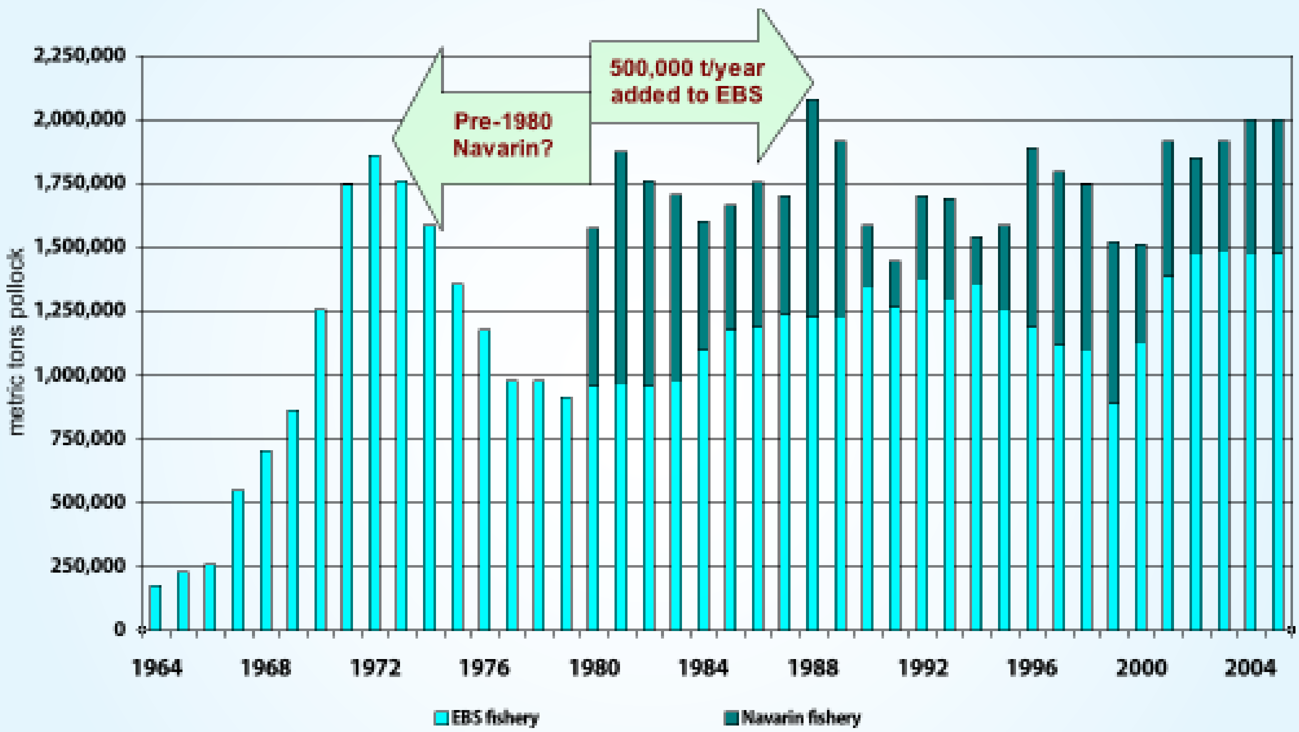
It is impossible to prove that the ABC values of recent years have been deliberately inflated, but there is no doubt that the pollock industry is happy with a relatively stable catch level and that fishery managers are happy to point to the high ABC values as proof of their conservative TAC setting. In any case, the claim that Bering Sea pollock catches are "conservative" and "safe" based on current TAC levels should be viewed as hypothesis rather than fact. As Field observed, determining the "correct" point estimate of yield corresponding to the target fishing mortality rate is a procedure fraught with huge uncertainty even for Bering Sea pollock, which has the best data and the most sophisticated stock assessment:

> *As an example of how error is quantified in stock assessment results, the 1999 assessment for Eastern Bering Sea pollock (NMFS 2000, citing Ianelli et al. 1999) included estimates of uncertainty associated with three alternative fishing mortality rates; F_{MSY}, $F_{40\%}$ and $F_{30\%}$. The $F_{40\%}$ strategy suggested a point estimate of 1.013 million metric tons as the appropriate yield, yet the 50% confidence limits for this estimate were 0.6 million to 1.7 million metric tons and the 95% confidence limits were between 0.2 and 3.0 million metric tons. The expected probability of overfishing with the target yield was 30% in that example, but perhaps most important is that this stock is the only one assigned to the highest data-quality tier in the North Pacific Council jurisdiction.*[40]

NAVARIN BASIN POLLOCK FISHERY: STRADDLING STOCK ISSUES

Eastern Bering Sea pollock is a stock that straddles U.S. and Russian waters. It has a continuous distribution into Russian waters from the Pribilof Islands to Cape Navarin. With the collapse of the western Bering Sea pollock stock in the early 1990s, a large Russian-flagged factory trawl fleet has fished the pollock stock in the Navarin region of the northwestern Bering Sea. Reported catches from 1980-2005 averaged greater than 500,000 t/yr and total catches for the period were approximately 12-13 million t, based on data provided by Ianelli et al (see Figure 13).[41] However, there is uncertainty in the catch records for this fishery. Illegal and unreported fishing are a problem in Russian waters. "Official" pollock catch statistics in the Navarin region vary from source to source (see Table 18).

FIGURE 13. EASTERN BERING SEA AND NAVARIN POLLOCK CATCH HISTORIES FOR AVAILABLE YEARS OF DATA, 1964–2005



SOURCE: Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea, in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions*, comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (Anchorage: NPFMC, 2005).

TABLE 18. THREE SOURCES OF NAVARIN POLLOCK CATCH STATISTICS FOR AVAILABLE YEARS, 1980-2005			
	Vasilyev (2004)	Stepanenko & Nikolaev (2005)	Ianelli et al. (2005)
1980			620,000
1981			900,000
1982			804,000
1983			722,000
1984		503,000	503,000
1985		488,000	488,000
1986		570,000	570,000
1987		463,000	463,000
1988		852,000	852,000
1989		684,000	684,000
1990		232,000	232,000
1991		178,000	178,000
1992		315,000	315,000
1993		389,000	389,000
1994	288,900	178,000	178,000
1995	427,300	320,000	320,000
1996	753,000	701,000	701,000
1997	735,000	680,000	680,000
1998	719,700	644,000	644,000
1999	639,000	633,000	633,000
2000	507,000	378,000	378,000
2001	526,000	526,000	526,000
2002	370,000	383,000	370,000
2003	411,200	416,000	425,000
2004	380,000	455,000	520,000 (est.)
2005	550,000 (TAC)	n/a	522,000 (est.)

The Navarin catch is additive to the catch of the U.S.-flagged fleet, since catches are believed to consist predominantly of eastern Bering Sea-spawned pollock cohorts that would otherwise return to spawn as adults in U.S. waters.[42] In effect, the EBS pollock catch of recent years has been not approximately1.5 million t/yr but approximately2 million t/yr — far higher than the stock assessment ABCs in most years prior to 2001 and at or above present ABC levels. The actual exploitation rate on the EBS pollock stock may therefore be significantly higher than the 18–20% estimated for the domestic fishery — perhaps as high as 30%, according to past estimates by the BS/AI Plan Team.[43]

Research from the Fisheries-Oceanography Coordinated Investigations (FOCI) program indicates that pollock migrate widely around the Bering Sea basin during summer foraging trips and therefore could "experience two independent sources of fishing mortality in two management regions."[45] Kotwicki et al. underscore the need to account for Navarin pollock fishery mortality in the management of the EBS fishery:

> *We conclude that a significant part of the EBS pollock population migrates into the Navarin-Anadyr area, which can have an impact on the way the EBS stock is managed. We should account for landings of pollock in the*

> *Navarin-Anadyr area, estimate how much of these landings include pollock from the EBS stock, and use this estimate in determining the EBS total allowable catch. Further research is needed to quantify the proportion of the EBS stock migrating into the Russian fishing zone and to estimate the number of pollock caught there.*[45]

Although Ianelli et al.[46] have modeled the Navarin fishery as part of the EBS pollock "stock" for comparative purposes, the Russian exploitation of the stock is not factored into the reference model from which OFL and ABC values are estimated for the U.S. fishery.

BOGOSLOF/ALEUTIAN BASIN POLLOCK

Although the goal of the North Pacific overfishing definition is to ascend the ladder toward Tier 1 management under MSY parameters with greater information over time, it is also possible for a stock to be demoted to a lower tier. Consider the rationale for the reclassification of the Bogoslof/Aleutian Basin pollock stock from Tier 3 to Tier 5 in 2000:

> *Last year, the SSC [Scientific and Statistical Committee] determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, with values of 2,000,000 t, 0.27, and 0.37 respectively, and that Bogoslof pollock therefore qualified for management under Tier 3 (the $B_{40\%}$ estimate of 2,000,000 t presumably includes both males and females). This year's assessment includes an age-structured model for Bogoslof pollock that calls the $B_{40\%}$ estimate of 2,000,000 into question. The new age-structured model gives a females-only $B_{40\%}$ estimate of 96,8000 t, which is a full order of magnitude lower than the previous estimate, even after correcting for the combined-sexes nature of the old estimate... The Plan Team thus recommends that Bogoslof pollock be moved from Tier 3 down to Tier 5, based on the following rationale: 1) Until questions surrounding computation of $B_{40\%}$ for this stock are resolved, it is not clear that a reliable estimate of this quantity exists, which implies that Bogoslof pollock should move down to at least Tier 4. 2) Given that there has been no fishery on this stock for so long and that selectivity patterns estimated for the shelf stock are probably not applicable to the deep-water Bogoslof stock, it is not clear that a reliable estimate of fishery selectivity — and thus $F_{40\%}$ — exists, which implies that Bogoslof pollock should move down to at least Tier 5. 3) It appears that a reliable estimate of natural mortality (0.20) does exist, which places Bogoslof pollock in Tier 5. The Plan Team also notes that placement of Bogoslof pollock in Tier 5 would classify it similarly with Aleutian pollock, a stock which generally has about the same quality of assessment information.*[47]

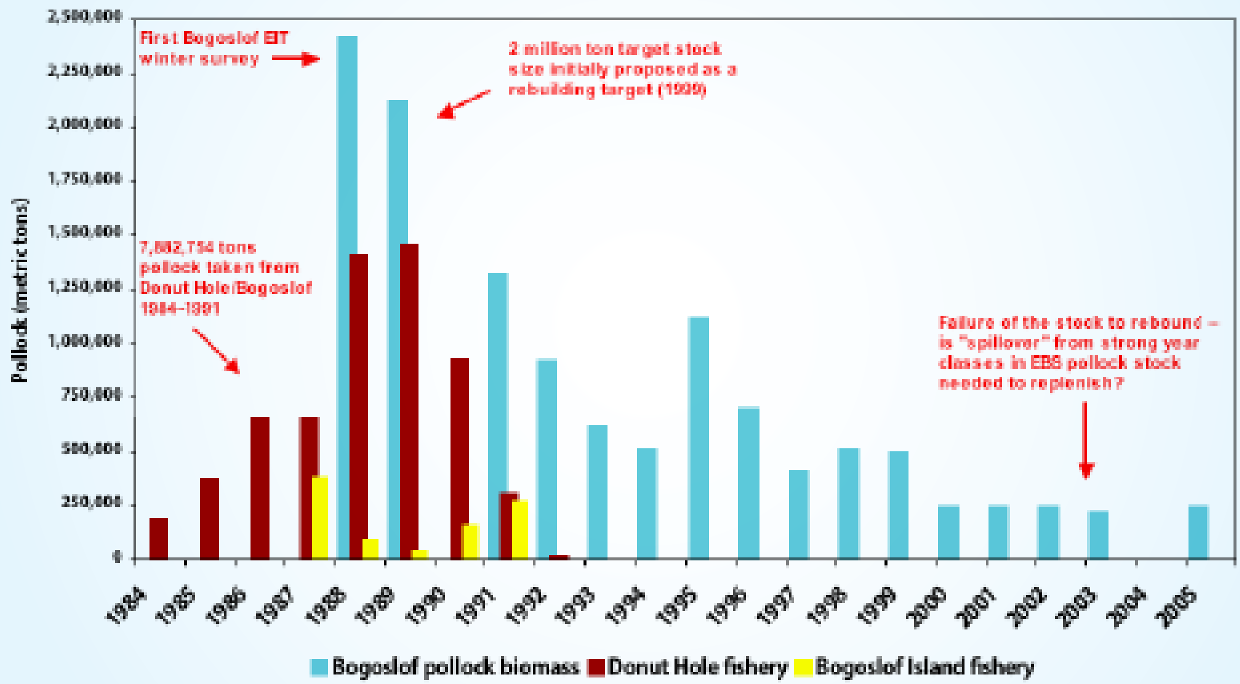
The abrupt reversal was due to the fact that "the senior assessment author has not been able to reproduce the calculations that led to the original acceptance of the old estimate several years ago."[48] The old estimates were judged to be inaccurate because the model was unable to fit the data and the stock was not rebounding from the massive fishing effort that occurred from 1987–1991. Serial depletion of spawning pollock aggregations along the Aleutian chain during the 1990s may have exacerbated this decline, since the stock structure is not well defined.[49]

Currently, the stock is managed under Tier 5, but recent efforts to develop an age-structured stock assessment model could lead to a re-evaluation of the status of Bogoslof pollock in the near future.[50]

ALEUTIAN BASIN POLLOCK ABUNDANCE TRENDS

Acoustic survey biomass trends for the Bogoslof/Aleutian Basin stock indicate continued declines and chronic low biomass despite a moratorium on pollock fishing since 1992. The 2005 survey estimate of approximately 250,000 t is only 10–12% of the biomass estimate from the first survey in 1988, and there is no indication of strong recruitment to the stock since the mid-1990s.

FIGURE 14. BOGOSLOF/ALEUTIAN BASIN POLLOCK STOCK TRENDS, 1984–2005



SOURCE: James Ianelli et al., "An Age-Structured Assessment of Pollock (Theragra chalcogramma) from the Bogoslof Island Region," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

Furthermore, pollock abundance in the Basin may be related to strong year classes on the shelf:

> *Data on the age structure of Bogoslof-Basin pollock show that a majority of pollock in the Basin originated from year-classes that are strong on the shelf, 1972, 1978, 1982, 1984, and 1989. The mechanism causing pollock to move from the shelf to the Basin appears to be density related, with the abundance in the Basin proportional to year-class size … Recruits to the Basin are coming from another area, most likely the surrounding shelves either in the U.S. or Russian EEZ.*[51]

If true, rebuilding and replenishment of the Aleutian Basin pollock population would be dependent on the density dependent "spill-over" effect from superabundant year classes in adjacent areas of the eastern Bering Sea. However, there is no consideration of the need to allow this density dependent process to function when the eastern Bering Sea pollock ABC level is set. If the EBS pollock fishery takes the surge of new "recruits" from a larger-than-average year class out of the population, those maturing fish may not migrate into outlying areas, in which case hopes for rebuilding the Bogoslof/Aleutian Basin pollock stock appear dim.

BOGOSLOF POLLOCK

For the Bogoslof stock, the 2005–2006 ABC and OFL were based on Tier 5 of the overfishing criteria, which does not permit an evaluation of stock status relative to overfishing criteria. Since 1999, several alternative methods of computing ABCs have been proposed:

1. Relative to a target stock size of 2 million tons, based on early biomass estimates from Bogoslof EIT surveys.

Since 1999, the NFPMC's SSC has recommended a formula in which Bogoslof pollock ABC is reduced relative to a rebuilding target stock size of 2 million t. Using this approach, the 2005 ABC would be 2,570 t, enough for bycatch purposes in other directed fisheries.[52]

2. Tier 5 using most recent survey biomass estimate and an estimate value for natural mortality.

Alternatively, the 2005 survey biomass is multiplied by 75% of natural mortality (M) (253,000 × M × .75). Depending on the choice of M, ABC is very different:

253,000 × .30 × .75 = 56,925 t
253,000 × .20 × .75 = 37,950 t

3. Tier 3, using the age-structured model proposed by NPFMC.[53]

In the past, the SSC has considered an age-structured model inappropriate because the assessed population is thought to cover only part of the stock (i.e., Bogoslof, not the sole source of Aleutian Basin pollock). Therefore, there is a high risk of model mis-specification for this "stock."[54]

Based on the proposed reference model, the age-5+ biomass at the beginning of 2006 is projected at 626,000 t, well above the 2005 Bogoslof EIT survey biomass estimate. The 2006 spawning biomass is projected to be 257,183 t, nearly two times the model-derived $B_{40\%}$ target stock size value of 133,270 t. Thus, Bogoslof pollock would fall into Tier 3a of Amendment 56 and the maximum permissible $F_{40\%}$ yield in 2006 would be 184,085 t (see Tables 19, 20).

TABLE 19. AGE-STRUCTURED MODEL REFERENCE POINTS AND PROJECTED 2006 BOGOSLOF POLLOCK SPAWNING STOCK BIOMASS

Female spawning biomass reference levels	Model results	Model 2006 spawning biomass
$B_{100\%}$	333,176	257,183 t (= $B_{77\%}$)
$B_{40\%}$	133,270	
$B_{35\%}$	116,612	

SOURCE: James Ianelli et al., "An Age-Structured Assessment of Pollock (Theragra chalcogramma) from the Bogoslof Island Region," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

TABLE 20. TIER 3A MAXIMUM PERMISSIBLE ABC AND OFL VALUES FOR 2006

Harvest strategy	$F_{SPR\%}$	Model 2006 projected yield
F_{ABC}	$F_{40\%}$	184,085 t
F_{OFL}	$F_{35\%}$	232,611 t

SOURCE: James Ianelli et al., "An Age-Structured Assessment of Pollock (Theragra chalcogramma) from the Bogoslof Island Region," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

Such a high level of fishing on the Bogoslof spawning aggregation has not been seen since 1990–1991, at the end of the pollock roe fishery. For the moment, Ianelli et al.[55] concur with the judgment that uncertainty in the stock structure and lack of information on the distribution of Bogoslof pollock pre-recruit juveniles support a decision to set ABC at bycatch-only levels.

However, the proposed model illustrates the perils of SPR% strategies based on running averages of a time series of recruitment and biomass. In a chronically declining stock, this results in new baselines far below stock levels at the start of the fishery and survey data time series. The diminished state of this depleted stock becomes the new, shifted baseline and reference level for a stock at carrying capacity, in which case the high abundance of Bogoslof/Aleutian Basin pollock in the 1980s is dismissed as a rare recruitment event and the stock is declared "healthy" once more.

Although the Bogoslof spawning grounds remain closed to directed fishing in District 518 in 2006, the fish may be subject to fishing mortality in other management areas at other times of year:

- If the Bogoslof pollock migrate into summer foraging areas where fishing is permitted (e.g., eastern Bering Sea shelf/slope or Navarin basin), they may experience substantial fishing mortality.
- Serial depletion of spawning pollock aggregations along the Aleutian chain during the 1990s may have exacerbated the decline of Bogoslof pollock, and reopening of the Aleutian Islands pollock fishery under Amendment 82 may impose additional mortality in 2006 and beyond.
- There is no current way of knowing if Bogoslof/Aleutian Basin pollock are straying into other management areas on their annual foraging migrations and dying in trawl nets.

ALEUTIAN ISLANDS POLLOCK

Aleutian Islands (AI) pollock has been closed to directed fishing since 1999, due to low biomass and high uncertainty. The decision to close the fishery by a vote of the NPFMC in 1998 followed a BS/AI Plan Team recommendation for a moratorium on directed fishing for AI pollock going back to 1996:

> *…[T]he Plan Team believes that the Aleutian pollock fishery should be managed on a bycatch-only basis for the following reasons: 1) the trawl survey time series indicates that the Aleutian pollock biomass has declined sharply and consistently since 1983, and gives no reason to expect an upturn in the foreseeable future; 2) some fish captured in the Aleutian Islands region may be part of the Aleutian Basin stock, a stock on which fishery impacts should be minimized; and 3) pollock has been shown to be an important prey item for Steller sea lions.*[56]

Since the closure of the fishery, the "stock" has been managed under Tier 5 criteria because reliable estimates of reference points corresponding to F_{MSY}, $F_{35\%}$, $F_{40\%}$, or $B_{40\%}$ could not be estimated for Aleutian pollock. In 2004, however, a new stock assessment provided estimates of $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$, and the BS/AI Plan Team adopted them, elevating this stock to Tier 3 status and indicating that it is not overfished. In 2005, the Plan Team reversed itself and followed the lead of the NPFMC's SSC, which recommended keeping AI pollock in Tier 5 pending better information.

Meanwhile, Congressional intervention has effectively forced the NPFMC to re-open the AI pollock fishery. In February 2005, NMFS issued a final rule that provided for the implementation of Amendment 82 to the BS/AI FMP, in compliance with a legislative provision advanced by Alaska Senator Ted Stevens. Amendment 82 establishes a framework for the management of the Aleutian Islands pollock fishery and requires that up to 19,000 t of the AI pollock TAC be allocated to the Aleut Enterprise Corporation for the purpose of economic development in Adak, Alaska.

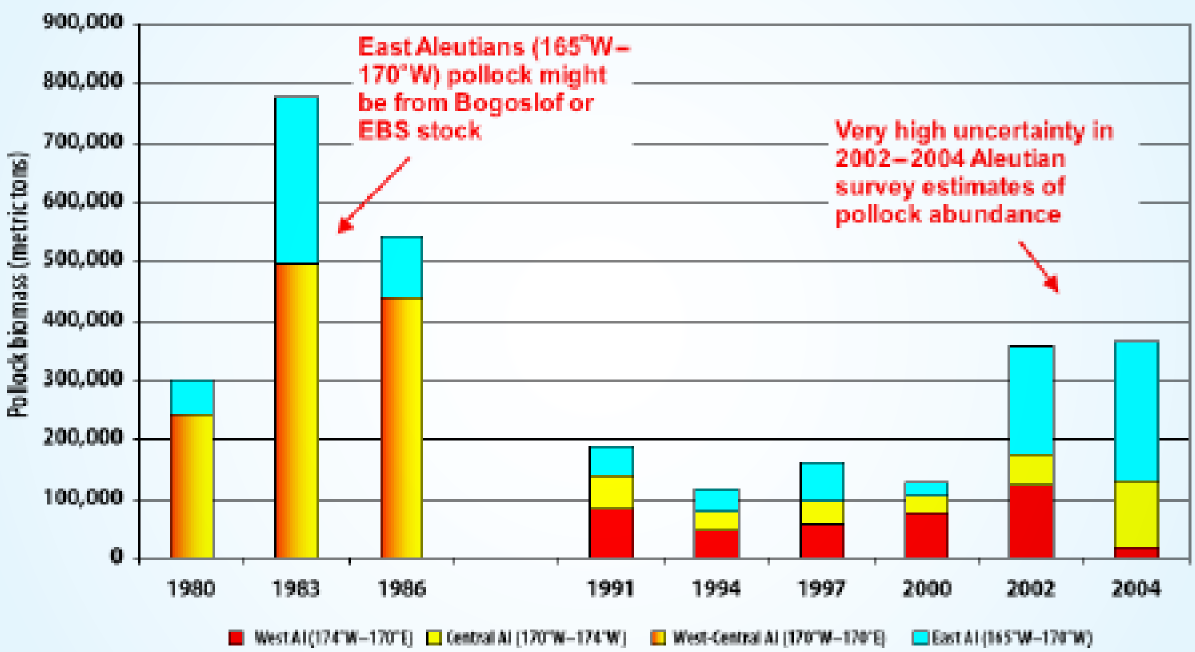
A decision to re-open the Aleutian pollock fishery under the terms of Amendment 82 is currently in limbo, with State of Alaska officials proposing a state-waters fishery independent of the federal management system and the NPFMC calling for NMFS to re-initiate consultation under the Endangered Species Act (ESA) to determine the effects of the proposed state-waters fishery on ESA-protected Steller sea lions. The NPFMC fears that the state-waters fishery proposal may trigger new ESA litigation.

ALEUTIAN ISLANDS POLLOCK ABUNDANCE TRENDS

The Aleutian Islands region pollock "stock" has declined steadily in the surveys since the early 1980s. The Aleutian groundfish trawl survey biomass estimates for this population have ranged from 20–50% of the value in the early 1980s, when systematic trawl surveys began, but a large portion of the biomass may come from fish of Bogoslof/Aleutian Basin or eastern Bering Sea origin.

If the pollock east of 170°W (eastern Aleutians) are excluded from the survey, the remaining "stock" is very small and remains below the levels estimated in the early/mid-1980s. Indications of a rebound in the last two surveys are highly uncertain and depend mainly on the inclusion of the eastern Aleutians portion of the survey area as part of the Aleutian "stock" (see Figure 15).

FIGURE 15. ALEUTIAN ISLANDS POLLOCK BIOMASS ESTIMATES, 1980-2002



SOURCE: Steve Barbeaux et al., "Stock Assessment of Aleutian Islands Region Pollock," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004).

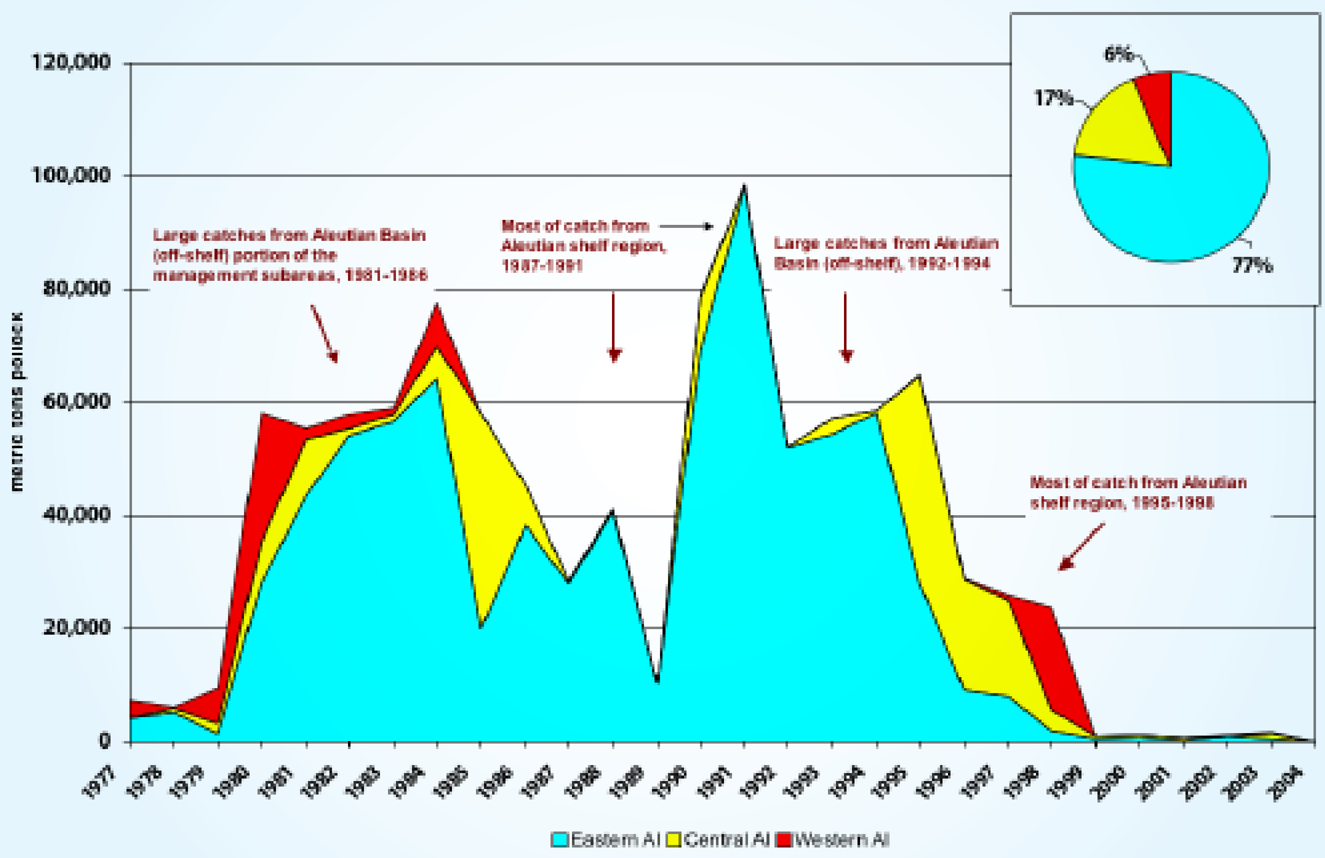
The amount of interaction between the Aleutian stock and the EBS stock is unknown. Assessment authors concluded that the abundance and composition of the eastern AI stock are highly confounded with those of the EBS stock. Therefore, overestimation of the AI pollock stock productivity because of the influx of the EBS stock is a significant risk.[57]

In addition, AI bottom trawl survey estimates of biomass are uncertain, with an average CV of 0.34. The 2002 and 2004 estimates are especially uncertain, with CVs of 0.38 and 0.78, respectively.[58] This uncertainty casts considerable doubt on the model projections of abundance and ABC estimates, compounded by the uncertainty in degree of interaction with adjacent stocks in the Bering Sea and western Gulf of Alaska:

- ❖ Very little is known about the AI pollock stock structure and its relation to the western Bering Sea, eastern Bering Sea, Gulf of Alaska, Bogoslof, and central Bering Sea pollock.
- ❖ Studies are needed on migration of pollock to understand how the stocks relate spatially and temporally, and how neighboring fisheries affect local abundances.

Review of fishery history by subareas indicates that eastern Aleutian pollock accounted for 77% of the catch in the past, and much of the rest may have been Bogoslof/Aleutian Basin pollock, or perhaps EBS pollock. Only from 1987–1991 and 1995–1998 were on-shelf catches significant in the west-central Aleutians region,[59] and the pollock in those areas apparently experienced rapid decline from the mid-1980s to mid-1990s, showing a pattern of serial depletion from east to west in the last years of the fishery, as seen in Figure 16.

FIGURE 16. ALEUTIAN ISLANDS POLLOCK CATCH, 1977–1998



SOURCE: Steve Barbeaux et al., "Stock Assessment of Aleutian Islands Region Pollock," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004).

STOCK STATUS OF ALEUTIAN POLLOCK: MUCH DEPENDS ON DEFINITION OF STOCK STRUCTURE

For the Aleutian Islands stock, the 2005–2006 maxABC and OFL were based on Tier 5, which does not permit an evaluation of stock status relative to overfishing criteria. Assessment authors recommended moving AI pollock from current Tier 5 status into Tier 3a (i.e., maxABC = $F_{40\%}$) of the control rules, based on reference Model 1 of the assessment for 2005. However, the new reference assessment model has two very different outcomes depending on the inclusion or exclusion of eastern Aleutian (165°W–170°W) pollock:[60]

- ❖ Excluding the eastern Aleutians (Model 1), the stock biomass is estimated to be just above $B_{40\%}$ at 54,400 tons ($B_{40\%}$ target = 53,900 t); the $B_{100\%}$ reference level is only about 135,000 t.
- ❖ Including the eastern Aleutians (Model 1B), the $B_{100\%}$ value is only 192,500 t, but standing stock biomass is projected to be at $B_{68\%}$ (131,000 t).

The differences in stock biomass between the two models have implications for ABC recommendations, resulting in a nearly three-fold increase in Model 1B because the model estimates more surplus spawning-age fish (i.e., spawning biomass above the $B_{40\%}$ target stock size) in need of culling (see Tables 21 and 22).

TABLE 21. MODEL REFERENCE LEVEL PROJECTIONS (IN METRIC TONS) FOR ALEUTIAN ISLANDS POLLOCK IN 2005

Female spawning biomass	Model 1	Model 1B	Model 1 2005 biomass	Model 1B 2005 biomass
$B_{100\%}$	134,900	192,500	54,400	131,000
$B_{40\%}$	53,900	77,000		
$B_{35\%}$	47,200	67,400		

SOURCE: Steve Barbeaux et al., "Stock Assessment of Aleutian Islands Region Pollock," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004).

TABLE 22. MODELS 1 AND 1B PROPOSED 2005 ABCS FOR ALEUTIAN ISLANDS POLLOCK

Harvest strategy	$F_{SPR\%}$	2005 projected yield (metric tons)
Model 1 F_{ABC}	$F_{40\%}$	27,900
Model 1 F_{OFL}	$F_{35\%}$	34,200
Model 1B F_{ABC}	$F_{40\%}$	80,500
Model 1B F_{OFL}	$F_{35\%}$	99,300

SOURCE: Steve Barbeaux et al., "Stock Assessment of Aleutian Islands Region Pollock," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004).

Although the proposed 2005 ABC recommendation was based on reference Model 1 and would have been the "conservative" alternative to Model 1B, that level of fishing would be comparable to the scale of the mid- to late-1990s fishery, which was characterized by a pattern of serial depletion of small, patchily distributed spawning aggregations. In 2005, the BS/AI Plan Team decided to follow the recommendation of the NPFMC's SSC that AI pollock remain a Tier 5 stock pending better information.

2005–2006 ALEUTIAN ISLANDS ABC RECOMMENDATIONS

In 2005–2006, in accordance with Senator Stevens' legislation, the Aleutian Islands TAC has been set at 19,000 t (see Table 23).

TABLE 23. ALEUTIAN ISLANDS POLLOCK STOCK ASSESSMENT STATUS AND CATCH SPECIFICATIONS (METRIC TONS), 2003–2006

Year	Tier	Survey age 3+ biomass (t)	Overfishing level (OFL)	Acceptable biological catch (ABC)	Total allowable catch (TAC)	Catch
2003	5	175,000	52,600	39,400	1,000	1,653
2004	5	175,000	52,600	39,400	1,000	1,150
2005	5	344,000	39,100	29,400	19,000	1,621
2006	5	n/a	39,100	29,400	19,000	n/a

SOURCE: Steve Barbeaux et al., "Stock Assessment of Aleutian Islands Region Pollock," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004, 2005).

NOTES

SHIFTING BASELINES AND MOVING TARGETS

[1] NMFS, *Environmental Assessment for Amendments 56/56 to the Fishery Management Plans of the Bering Sea/Aleutian Islands and Gulf of Alaska, To Redefine Acceptable Biological Catch and Overfishing* (1999), 11.

[2] NMFS, 63 FR 24216 (1998).

[3] NMFS, *Alaska Groundfish Fisheries Draft Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2001), 74 [hereafter report cited as *2001 Draft PSEIS*].

[4] The origins of this approach can be traced to the work of Ricker (1954) and others in the 1950s who developed mathematical formulas to describe the reproduction curves of fish and the relationship between numbers of spawning fish and recruitment. The SPR% strategies emerged in the 1990s (Clark 1991; Mace 1994) with the North Pacific and Pacific regions adopting them (Tim D. Smith, *Scaling Fisheries: The Science of Measuring the Effects of Fishing, 1855-1955* [Cambridge: Cambridge University Press, 1994], 288-292).

[5] John C. Field, *A Review of the Theory, Application and Potential Ecological Consequences of $F_{40\%}$ Harvest Policies in the Northeast Pacific* (2002: Alaska Oceans Network).

[6] NMFS, 63 FR 24220 (1998).

[7] NMFS, *Endangered Species Act Section 7 Consultation—Biological Opinion and Incidental Take Statement* (2000), 208, 223-224.

[8] Pamela M. Mace, "Relationships Between Common Biological Reference Points Used as Thresholds and Targets of Fisheries Management Strategies," *Canadian Journal of Fisheries and Aquatic Sciences* 51 (1994).

[9] Andrew Rosenberg, Pamela Mace, and G. Thompson, et al., *Scientific Review of Definitions of Overfishing in U.S. Fishery Management Plans*, NOAA Technical Memorandum NMFS-F/SPO-17 (Washington, DC: U.S. Department of Commerce, NOAA, 1994).

[10] Daniel Goodman, Marc Mangel, and Graeme Parks, et al., *Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Fishery Management Plans— Draft report* (Anchorage: NPFMC, 2002).

[11] David Witherell, Clarence Pautzke, and David Fluharty, "An Ecosystem-Based Approach for Alaska Groundfish Fisheries," *ICES Journal of Marine Science* 57 (2000), 771-777.

[12] TAC was set at 100% of ABC in most years of the 1990s. In 2001, the stock assessment estimate of ABC was increased substantially. Since 2002, ABCs have been at the highest levels in the history of the stock assessments, and the EBS pollock TAC has been increased to the highest levels in the history of the domestic fishery.

[13] NPFMC and NMFS, *Final Environmental Impact Statement for the Bering Sea/Aleutian Islands Groundfish Fishery Management Plan* (1981).

[14] Witherell et al., *An Ecosystem-Based Approach*, 771-777.

[15] NMFS, *2001 Draft PSEIS*, 46: "Alternative 1 is structured around target species management and provides for many levels of protection for target species *mainly through the TAC-setting process* (Section 2.7.5). Annual TACs are based, in part, on the current status of groundfish stocks as well as a number of biological, ecological, and socioeconomic considerations."

[16] Echo-integration trawl (EIT) surveys use acoustic arrays to assess fish aggregations along spaced transects. Together with bottom trawl and long-line surveys, EIT surveys are one of the main fishery independent methods to estimate fish stocks.

[17] The Plan Team for the Groundfish Fisheries of the Gulf of Alaska, comp. [hereafter cited as "GOA Plan Team"], *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (Anchorage, Alaska: NPFMC, 2004), App. B [hereafter referred to as *2004 GOA SAFE*].

[18] Ibid., 57.

[19] Ibid.

[20] Ibid., Table 1.15.

[21] Ibid.

[22] Martin Dorn, Steven Barbeaux, and Sarah Gaichas, et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska,* comp. The Plan Team for the Groundfish Fisheries of the Gulf of Alaska (Anchorage, Alaska: NPFMC, 2004).

[23] GOA Plan Team, *2004 GOA SAFE*, App. B.

[24] James N. Ianelli, Steve Barbeaux, and Gary Walters, et al., "Eastern Bering Sea Walleye Pollock Stock Assessment," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions,* comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (Anchorage, Alaska: NPFMC, 2004), 52 [hereafter cited as *2004 EBS Pollock SAFE*].

[25] This column shows the maximum amount of the A season TAC that the fisheries can catch in the Sea Lion Conservation Area (SCA).

[26] Ibid., 10.

[27] Ibid.

[28] Except for historical records of commercially exploited sea otters, fur seals, and whales, the accounts of abundance and trends for most species in the Bering Sea are largely anecdotal or conjectural.

[29] Ianelli et al., *2004 EBS Pollock SAFE.*

[30] James N. Ianelli, Steve Barbeaux, and Taina Honkalehto, et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region ,* comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands. (Anchorage: NPFMC, 2005) [hereafter cited as *2005 EBS Pollock SAFE*].

[31] Ianelli et al., *2004 EBS Pollock SAFE.*

[32] Ibid.

[33] Ianelli et al., *2005 EBS Pollock SAFE.*

[34] Vidar G. Wespestad, "The Status of Bering Sea Pollock and the Effect of the 'Donut Hole' Fishery," *Fisheries* 18, no. 3 (1993): 18-24.

[35] James Ianelli. Personal communication.

[36] Ianelli et al*., 2004 EBS Pollock SAFE.*

[37] The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands, comp. [hereafter cited as "BS/AI Plan Team"], *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (Anchorage, Alaska: NPFMC, 2004), App. A, p. 11 [hereafter cited as *2004 BS/AI SAFE*].

[38] Ianelli et al., *2005 EBS Pollock SAFE.*

[39] One possible explanation for the recent increases in ABC and TAC is that industry rationalization under the American Fisheries Act, which ended the 1990s helter-skelter race for fish, is now being rewarded. In a closed-access fishery, managers have more confidence to raise ABC and TAC levels without incurring the risk of exceeding TAC or inviting new entrants into the fishery.

[40] Field, *A Review of the Theory*.

[41] The Plan Teams for the Groundfish Fisheries of the Bering Sea/Aleutian Islands and Gulf of Alaska [hereafter cited as "BS/AI and GOA Plan Teams"], *Draft Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (Anchorage: NPFMC, 2005) [hereafter cited as *2005 Draft SAFE*].

[42] (Wespestad et al. 1996, 1997; Pautzke 1997; SAFE reports, 1998, 1999, 2000, 2003, 2005).

[43] BS/AI Plam Team *meeting minutes*, 1996.

[44] S. Allen Macklin, ed., *Bering Sea FOCI 1991-1997, Final Report*, NOAA ERL Special Report (Seattle: Pacific Marine Environmental Laboratory, 1998), 46.

[45] Stan Kotwicki, Troy W. Buckley, and Taina Honkalehto, et al., "Variation in the Distribution of Walleye Pollock (*Theragra chalcogramma*) with Temperature and Implications for Seasonal Migrations," *Fishery Bulletin* 103 (2005): 574-587.

[46] James N. Ianelli, Steve Barbeaux, and Gary Walters, et al., "Eastern Bering Sea Walleye Pollock Stock Assessment," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions,* comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (Anchorage: NPFMC, 2003); Ianelli et al., *2005 EBS Pollock SAFE.*

[47] The Plan Teams for the Groundfish Fisheries of the Bering Sea/Aleutian Islands and Gulf of Alaska, *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (Anchorage: NPFMC, 1999), 11 [hereafter cited as *1999 SAFE*].

[48] Ibid.

[49] Ibid., 39.

[52] BS/AI and GOA Plan Teams, *2005 Draft Safe.*

[51] Ibid., 119.

[52] BS/AI Plan Team, *2004 BS/AI SAFE,* App. A.

[53] James N. Ianelli, Taina Honkalehto, and Neal Williamson, "An Age-Structured Assessment of Pollock from the Bogoslof Island Region," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources for the Bering Sea/Aleutian Islands Regions,* comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (Anchorage, Alaska: NPFMC, 2005).

[54] BS/AI Plan Team, *2004 BS/AI SAFE.*

[55] BS/AI Plan Team, *2005 SAFE*.

[56] BS/AI Plan Team, *1996 BS/AI SAFE.*

[57] Steve Barbeaux, James N. Ianelli, and Eric Brown, "Stock Assessment of Aleutian Islands Region Pollock," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions,* comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (Anchorage, Alaska: NPFMC, 2004).

[58] Ibid.

[59] Ibid.

[60] Ibid.

Indian Paintbrush, fireweed, and daisies in bloom along shoreline of Unalaska Bay, Unalaska Island, Alaska © 2006 Alaska Stock.

OVERFISHING IN AN ECOSYSTEM CONTEXT

There are three fundamental problems with the MSY/OY approach as fishery managers have applied it. First, there is an inherent, dangerous contradiction between 'maximum' and 'sustainable.' Sustainability is a sensible management objective: stewardship into the indefinite future should be part of any reasonable management strategy. Adding 'maximum' to the equation, however, creates an incentive to allow short-term considerations and ignorance of marine systems to cancel out the long-term promise of sustainability. When 'maximum' is combined with 'sustainable,' the emphasis shifts from sustaining both a fishery and an ecosystem to a narrow fishery production model that ignores the ecosystem.[1]

Is there uncertainty and risk to the environment as a result of authorizing the groundfish fisheries in the BSAI and GOA? Yes there is. We do not know the full effects of commercial fishing on the environment, nor do we understand the effects of fishing on the ecosystem and its processes.[2]

The MSA currently mandates that "conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery."[3] While the definition of "optimum yield" acknowledges the importance of protecting marine ecosystems and authorizes downward adjustments from the maximum allowable fishing rate "as reduced by any relevant economic, social, or ecological factor," it also prescribes optimum yield on the basis of MSY.[4]

The NPFMC uses the MSY approach to manage fisheries. The simplest way to describe this approach is that if one takes approximately 60% of the fish out of the stock's population by fishing, the remaining 40% will produce the maximum sustainable yield. Any new production in the "target" stock above the theoretical level needed to maintain the target stock (which is around 40% of its unfished level on average) is considered a surplus for the fishery.[5] As the 1999 Bering Sea/Aleutian Islands (BS/AI) FMP acknowledges, however, there is no surplus production in marine ecosystems for fisheries to take.[6,7] In the absence of the giant pollock fishery, the foregone catch would be turned not into fake crabmeat or fish sticks, but into more fur seals, sea lions, seabirds, whales, halibut, cod, and pollock.

The $F_{40\%}$ policy is the cornerstone of the NPFMC's claim of conservative management, resulting in allowable catch levels below the level that would be obtained from a strict F_{MSY} policy, on average.[8] However, this single-species approach to setting catch levels does not consider the following question: *What are the effects of fishing at a level that reduces fish stocks by 60% on average on competing predators and related and dependent species*?

The $F_{40\%}$ "harvest policy"[9] ignores the effects on the ecosystem and assumes that target species can be fished to the maximum sustainable yield level without significant consequences to dependent and related species in the food web:

- The NPFMC and National Standard 1 definitions of "overfishing" are premised on a rate of fishing mortality that avoids jeopardizing the capacity of a targeted fish stock to produce the MSY.
- Levels of exploitation on single stocks are set with no explicit consideration of the impacts of dependent competing species in the food web or other impacts on associated species that flow from the exploitation of commercially desirable species.
- Currently there is no policy framework within the NPFMC FMPs and no explicit procedures in the TAC-setting process to address the ecosystem-level impacts of single-species target fishing levels on dependent and related species in the ecosystem.

THE NORTH PACIFIC FISHERY MANAGEMENT PLANS DO NOT ADDRESS IMPACTS ON DEPENDENT SPECIES IN THE POLLOCK FOOD WEB

NMFS has acknowledged that trophic interactions (predator/prey dynamics) are not formally considered in the stock assessment advice under the status quo.[10] In other words, catch levels in the North Pacific are determined on the basis of single-species guidelines in the federal fisheries law that do not directly consider other consumers in the ecosystem.[11] The NPFMC does not account for the needs of predators or other ecosystem-level considerations when setting groundfish catch levels.[12] The management system treats each stock's allowable catch levels in isolation from its relation to the ecosystem.[13]

Nearly a decade ago, the National Research Council highlighted the NPFMC's failure to address the needs of ecosystem consumers of Bering Sea pollock, such as the Steller sea lion and northern fur seal:

> *Fundamental conflicts between the usual goals of maximizing yields in marine fisheries management and the goals of the Endangered Species Act, Marine Mammal Protection Act, and National Environmental Policy Act remain unresolved even at the federal level in the National Marine Fisheries Service, as illustrated by the present groundfish management by the North Pacific Fishery Management Council, which does not explicitly orient management to provide additional food resources for the threatened Steller sea lion or for other declining marine mammals and seabirds in the Bering Sea and Gulf of Alaska*.[14]

The pollock fishery reduces the overall availability of pollock to competing sea lions and fur seals, and NMFS has recognized the potential of this strategy to reduce carrying capacity of competing predators in the ecosystem.[15] The spatially and temporally concentrated nature of the pollock fishery amplifies the cumulative, ecosystem-wide effect, and may deplete prey availability at smaller spatial scales and shorter time scales that last days, weeks, or even years within a particular area or region.[16] Based on these considerations, NMFS concluded in 1998 and again in 2000 that the pollock fisheries are likely to jeopardize Steller sea lion survival and recovery and adversely modify sea lion critical habitat.

Puffin © Greenpeace/Visser.

In the court-ordered *Alaska Groundfish Fisheries Programmatic Supplement Environmental Impact Statement* on North Pacific groundfish management plans,[17] NMFS concluded that the "question of whether commercial fisheries contribute to either an overall scarcity of prey or localized depletion of prey cannot be answered with certainty."[18] NMFS found that the mechanisms and causal pathways for many potential food web effects are poorly documented, and the information needed to assess the effects of groundfish fishery harvests on the marine mammal prey field is generally unavailable.[19] Imprecision in the survey distributions of stock biomass at both small and large spatial-temporal scales is a major impediment to quantifying the impact of the pollock fishery on prey availability and foraging success of pollock predators.

The difficulty is compounded by the inability of fishery stock assessments to assess the spatial distribution of stock biomass, the movement of fish over the course of the year, or the spatial and temporal effects of fishing. Stock assessments compute estimates of ABC at the area-wide scale of the "stock as a whole" and on a start-of-year basis,[20] but fisheries concentrate effort in highly productive areas and times of high CPUE for economic reasons. Spatial-temporal concentrations of fisheries increases the risk of overfishing and depleting target stocks at local or regional scales; separate ESA consultations on the fisheries have already concluded that spatially and temporally concentrated fishing for pollock and other species poses a threat to competing predators, such as the Steller sea lion, that rely on these aggregated fish stocks.[21]

The information that NMFS says is required to quantify fishery impacts on marine mammal food supplies and habitat will entail decades of sustained research funding and field work:

> *To make a determination of the point at which the alternative fishery regimes affect the availability of key prey species . . . it is necessary to know the following: the marine mammal's energy requirements; the relative contribution of each prey species to those energy requirements; the adequacy of the existing standing biomass of prey; the standing biomass of the prey species before and after the fishery; and how the change in standing biomass equates to changes in the marine mammal population's vital rates or carrying capacity. With the best scientific and commercial data, our current understanding of marine mammal bioenergetic requirements does not allow such a determination.*[22]

Given the inherent difficulties of conducting research in the open ocean environment and the limits of research budgets, that scientific evidence could be a long time coming. As noted by NMFS, marine science is likely to provide glimpses of underlying ecosystem mechanics rather than complete understanding for the foreseeable future.[23] And in the absence of baseline historical information that would allow a comparison between the current state of the ecosystem and an unfished environment, the causes of ecosystem changes in a complex system can always be argued.[24]

The question then becomes: ***Who bears the burden of proof in the meantime — the fisheries or the ecosystem?***

The uncertainties described above underscore the need for a more precautionary approach to fisheries management in the context of food web and habitat conservation, and illustrate why NMFS's National Environmental Policy Act determinations of "insignificance" for fishery impacts on prey availability and spatial-temporal concentration of fisheries are arbitrary. NMFS cannot demonstrate that the current and proposed levels of fishing permitted in at-risk protected species' habitats are "safe" or "insignificant." Rather, NMFS assumes that the impact is insignificant in the absence of conclusive evidence to the contrary. This is the opposite of a precautionary, ecosystem-based approach.

THE $F_{40\%}$ STRATEGY DOES NOT CONSIDER ECOSYSTEM NEEDS

The single-species management approach aims to maintain fish stocks at approximately 40% of their unfished biomass ($B_{40\%}$) by removing approximately 60% of the stock. Absent enough information on a specific fish stock to calculate the MSY level, the proxy of $B_{40\%}$ is used.[25] This is the lower target stock size that management aims for by fishing at $F_{40\%}$, a level of fishing considered to be a conservative approximation of F_{MSY}.[26]

Goodman et al. emphasized that it is not obvious to what degree the $F_{40\%}$ policy's goal of achieving long-term catches near MSY is consistent with ecosystem needs:

> *The $F_{40\%}$ approach to estimating the ABC, by itself, is inherently a single species approach. It is thought that for most of the target species in the FMP, a fishing mortality rate of $F_{35\%}$ would be appropriate for achieving long-term catches near MSY, under the condition of an unchanged oceanographic regime . . . The decision to use $F_{40\%}$ rather than $F_{35\%}$ was deliberately protective, and was intended to function as a buffer against several sources of uncertainty, including the concern that theoretical models have shown that managing each species for its single species MSY will not achieve MSY for the aggregate. Nevertheless, it is not clear how much of the margin between $F_{35\%}$ and $F_{40\%}$ was 'allocated' to ecosystem considerations. Nor was a calculation carried out to demonstrate what amount of escapement is needed for ecosystem purposes, or to assess whether the margin between fishing at $F_{35\%}$ and $F_{40\%}$ supplies this amount.*[27]

Killer whale, Bering Sea © 2006 Todd Warshaw/Greenpeace USA.

Goodman and his colleagues asked whether this approach is considerate of ecosystem needs and concluded that the "conventional world view" of single-species fishery management fails to account for significant impacts of the MSY-based exploitation strategy on higher trophic levels of the food web:

> *A harvest management strategy, such as $F_{40\%}$, that by design reduces the biomass of the target stock biomass by a large fraction, will, all other things being equal, reduce the total consumption by higher trophic levels by a similar large fraction, and we would expect the predator populations to be reduced accordingly.*[28]

TABLE 24. POTENTIAL FISHERY EFFECTS, OUTCOMES, AND MANAGEMENT IMPLICATIONS FOR PREDATORS

Effect of the fishery	Possible outcome	Implications for management
Reduction in the spawning biomass of multiple target (prey) stocks (by 60% on average)	• Reduction in consumption of prey by predators by a similar amount • Could push predators over an energetic cost-benefit threshold, where predators now expend more energy searching for prey than they gain from consuming it	• Effects could be detrimental to the predator, even though the gross quantity of remaining prey biomass might be enough to supply the food demands of the predator • Difficult to detect effects by monitoring predator and prey populations
Changes in the age and size distribution of exploited fish populations, disproportionately reducing the abundance of larger size classes	Could disproportionately impact a predator dependent on depleted size class(es) during some stage of its life	Effect could operate at a level that negatively affects the predator, even though total prey biomass, summed over all prey-size classes, might be enough for the aggregate food demands of the predator population
Local and temporal depletions of multiple prey species	Could interfere with predator survival and reproduction if depletions occur near breeding sites or in important foraging areas	Computing the average prey availability might miss a critical local depletion for the predator

SOURCE: Daniel Goodman, et al., *Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Fishery Management Plans—Draft Report* (Anchorage, Alaska: NPFMC, 2002).

STELLER SEA LION JEOPARDY/ADVERSE MODIFICATION CONCLUSIONS IN THE 1998 AND 2000 ESA SECTION 7 BIOLOGICAL OPINIONS

In the December 1998 Steller sea lion Biological Opinion on the pollock and Atka mackerel fisheries, NMFS concluded that the intense spatial and temporal concentration of the pollock fisheries ("pulse fishing") within critical habitat jeopardizes Steller sea lions and adversely modifies sea lion critical habitat.

In the November 2000 Steller sea lion Biological Opinion on the North Pacific groundfish FMPs (FMP BiOp), NMFS explicitly acknowledged for the first time that the proxy MSY harvest policy ($F_{40\%}$) has reduced important Steller sea lion prey stocks to 40–60% of the expected unfished stock size over time.

Not only is the FMPs' $F_{40\%}$ harvest policy "reasonably likely to reduce significantly"[29] the availability of important prey to Steller sea lions, it is likely to reduce ecosystem carrying capacity (hence driving the decline or inhibiting recovery) to a significant extent:

> *[A] link was established in this effects section between this large-scale reduction in fish biomass and the carrying capacity of Steller sea lions in the BSAI and GOA. It is NMFS opinion that these biomass reductions of Steller sea lion prey species, along with other factors such as climate change, natural predators, etc., were a significant contributing factor of the reduction and current decline of the population of Steller sea lions.*[30]

The November 2000 Steller sea lion FMP BiOp marked the first time that NMFS assessed the combined and cumulative effects of the FMPs' default "harvest policy" ($F_{40\%}$ fishing mortality rate) on the ecosystem. Key findings include:

- **The goal of the MSY-based "harvest" policy is to remove fish before they are "lost" to natural mortality by other ecosystem consumers.**
- **Compared to an unfished stock, the "average" eastern Bering sea pollock is more than a year younger and 30% less in mean weight under an $F_{40\%}$ exploitation strategy. Such cumulative effects on the prey base would require sea lions to expend more energy foraging for the same energy input.**
- **Fishing under the $F_{40\%}$ harvest policy has reduced the potential spawning stock biomass of fully targeted species over the last 20 years.**
- **This long-term reduction on the order of 40–60% may significantly reduce the availability of prey to other components of the ecosystem, such as Steller sea lions.**
- **This stock-wide reduction in biomass diminishes carrying capacity of critical habitat for the Steller sea lions.**
- **Biomass reductions of important groundfish species below 40% of their unfished level would "not insure" the protection of listed species or their environment.**
- **Stock sizes for pollock, cod, and Atka mackerel below the $B_{40\%}$ target biomass constitute a "take" of Steller sea lions.**

The *cumulative*, ecosystem-wide effect of fishing down stocks under the MSY-based fishing exploitation rates is such that the value of critical habitat (the most important feature of which is prey) is diminished even before fishing starts at the beginning of every year. Thus, the November 30, 2000, FMP BiOp concluded that adverse effects of competitive fisheries occur at three temporal-spatial scales, including the "global" scale of the fishery, as well as the regional and local scale effects.[31]

To provide for the recovery of the Steller sea lion population toward historical levels, it is necessary to leave more prey in the water. This finding would seem to require NMFS and the NPFMC to address the "harvest" rate and the corresponding TAC levels, in addition to dispersing TACs temporally and spatially outside of sea lion critical foraging habitat.

However, the FMP BiOp balked at the politically difficult question of what alternative fishing rate and lower catch levels will enhance the prospect of recovery of Steller sea lions. It is only in the Administrative Record for the FMP BiOp that any written record of the question survived.[32]

BEYOND MSY: IS IT POSSIBLE TO QUANTIFY "ECOLOGICAL SUSTAINABLE YIELD" FOR A MARINE ECOSYSTEM?

Similar to the statutory mandates of forest management in the Multiple-Use Sustained Yield Act,[33] sustained yield under the MSA is focused on production of renewable natural resources for human use. Thus, "resource conservation" in the Magnuson-Stevens Act values nature primarily for extraction ("harvest"), and sustainability is defined in terms of productive output for fisheries, not stewardship of natural ecosystems or ecological integrity.[34]

However, there is no consensus metric of "ecosystem overfishing."[35] Lacking a ready way to quantify ecosystem considerations, how can fishery managers practically address the ecological shortcomings of MSY in the process of setting catch levels for large-scale commercial fisheries like the Alaska pollock fisheries?

When ecosystem considerations are incorporated into the TAC-setting process, it may be that that the "acceptable" or "optimum" level of fishing is considerably lower than the stock assessment modelers have recommended in the conventional context, based on yield goals for the fishery. Ultimately, the challenge is to **redefine fishery sustainability in an ecosystem context**. This means authorizing levels of fishing that are compatible with preserving the productivity, nutrient dynamics, trophic structure, species richness, and resilience of the natural ecosystem.[36]

ALTERNATIVES TO SINGLE-SPECIES MANAGEMENT

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) differs from conventional approaches to marine resource management in that the CCAMLR treaty is concerned not only with resource extraction and the regulation of fishing, but also with conservation of the whole ecosystem.[37] The "ecosystem approach" of CCAMLR is reflected in Article II of the treaty, in which the needs of dependent and related species in the food web are acknowledged and a precautionary approach to the whole is mandated:

> *An ecosystem approach does not concentrate solely on the species fished but also seeks to minimize the risk of fisheries adversely affecting 'dependent and related species,' that is, the species with which humans compete for food. However, regulating large and complex marine ecosystems is a task for which we currently have neither sufficient knowledge nor adequate tools. Instead, CCAMLR's approach is to regulate human activities (e.g. fishing) so that deleterious changes in the Antarctic ecosystems are avoided.*[38]


Steller sea lions in Bristol Bay © 1991 Greenpeace/Visser.

The CCAMLR approach to setting allowable fishing levels in the Krill Yield Management plan highlights the shortcomings of the North Pacific process. The first step of the krill (*Euphausia superba*) assessment, as in the North Pacific, is to estimate the yield level according to the single-species criteria, the goal being to have no greater than a 10% probability of the spawning stock falling below $B_{20\%}$.

In the second step, a reduction in the single-species fishing rate is applied to make more krill available to predators. Since a reliable quantitative model of fishery impacts on predators is not available, an "ad hoc approach" has been adopted — the reasoning being that the best management for krill predators would be no fishing at all. In an attempt to account for predator needs while still providing for a fishery, a preliminary target stock size halfway between the single-species $B_{50\%}$ target stock size and the stock size without fishing ($B_{100\%}$) was chosen, that is, 75% of unfished stock size ($B_{75\%}$):

> *The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) takes the needs of krill into account in an indirect manner when recommending the annual krill catch limit. This is done using a single species model to estimate the size of the krill population (relative to its pre-exploitation size) after a 20-yr period of harvesting at a given intensity. The level of harvesting intensity is adjusted until the median krill spawning biomass is predicted to be 75% of its median pristine size.*[39]

This management action to address trophic impacts of fishing was taken in a precautionary manner in the absence of certainty about the needs of krill predators:

> *In the absence of any suitable information on the needs of krill predators, this 75% figure was chosen simply because it lies halfway between 100% (i.e., no krill fishery) and 50% (the optimal depletion level suggested by the commonly used Schaeffer surplus production model…*[40]

This simple three-part "decision rule" is described as follows:

1. Establish a single-species exploitation rate "so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year period is 10%."[41]

2. Establish an adjusted exploitation rate "so that the median escapement in the krill spawning biomass over a 20-year period is 75% of the pre-exploitation median level."[42]

3. Choose the lower of the two values as the level for the calculation of the krill yield.

Currently, there is no Step 2 in the North Pacific groundfish ABC-setting process. In other words, a single-species target level like that in Step 1 of the CCAMLR rule is the only explicit consideration of management in the North Pacific. There is no explicit adjustment in ABC to account for other consumers in the ecosystem.

RECOMMENDATIONS FOR PRECAUTIONARY CATCH LIMITS IN THE NORTH PACIFIC

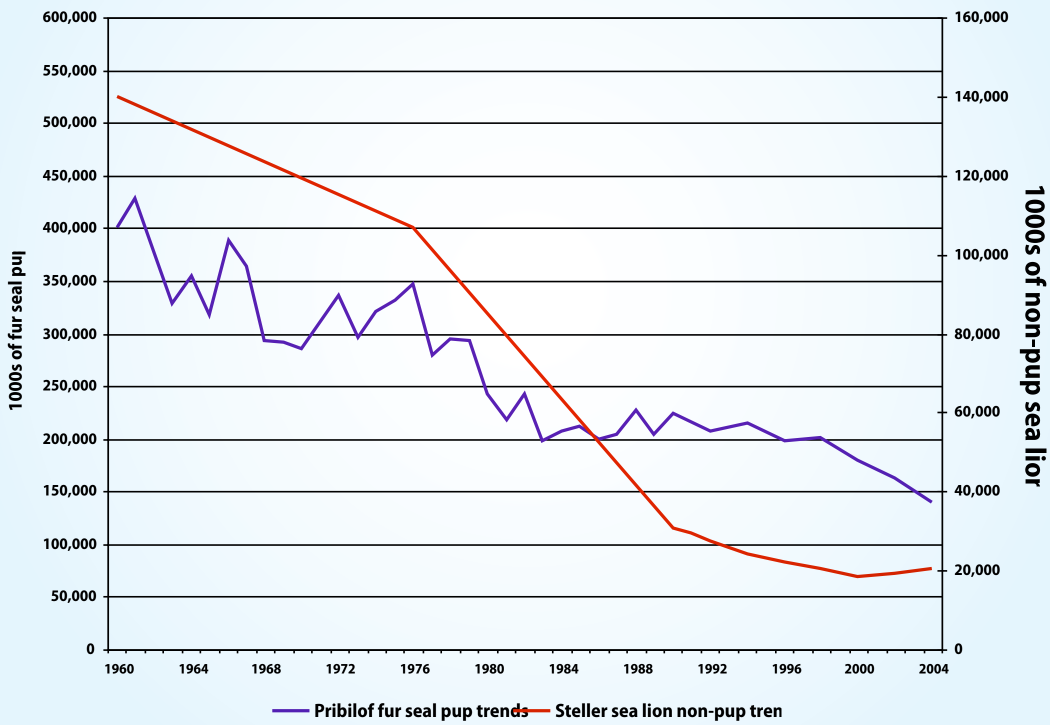
To compensate for the ecological deficiencies of MSY and the absence of explicit adjustments to ABCs to address ecosystem needs, environmental organizations have recommended that the NPFMC modify its overfishing guidelines to account explicitly for the roles of target species as prey for other fish, marine mammals, and birds, as well as the life history characteristics, habitat needs, and scientific uncertainties that make target species vulnerable to conventional MSY levels of fishing mortality.

An amended and reauthorized MSA should require fishing levels to be set in a precautionary manner to preserve ecological relationships between target species and dependent and related species in the ecosystem. The TAC-setting process should contain procedures to reduce allowable levels of fishing under the conventional single-species MSY rules to an optimum yield (OY) level that addresses both the cumulative effects of fishery-maximizing exploitation strategies designed to out-compete the other parts of the ecosystem, and local-scale impacts of spatial-temporal concentration of fishery catches.[43] The MSA should reduce fishing for important forage species to more precautionary levels to maintain the forage base for predators at high levels of abundance relative to the unfished condition as is done under the CCAMLR, which sets the harvest policy for important forage species such as krill at $F_{75\%}$ in an effort to take the needs of predators into account.[44]

STELLER SEA LIONS AND NORTHERN FUR SEALS: SPATIAL-TEMPORAL IMPACTS OF CONCENTRATED FISHING ON PREY AVAILABILITY AND HABITAT

The decline of ESA-listed Steller sea lions (*Eumetopias jubatus*) and MMPA-listed northern fur seals (*Callorhinus ursinus*) in western Alaska has persisted over three decades, confounding scientists' expectations for these long-lived species — and completely at odds with increasing trends for seals and sea lions from southeast Alaska to California.

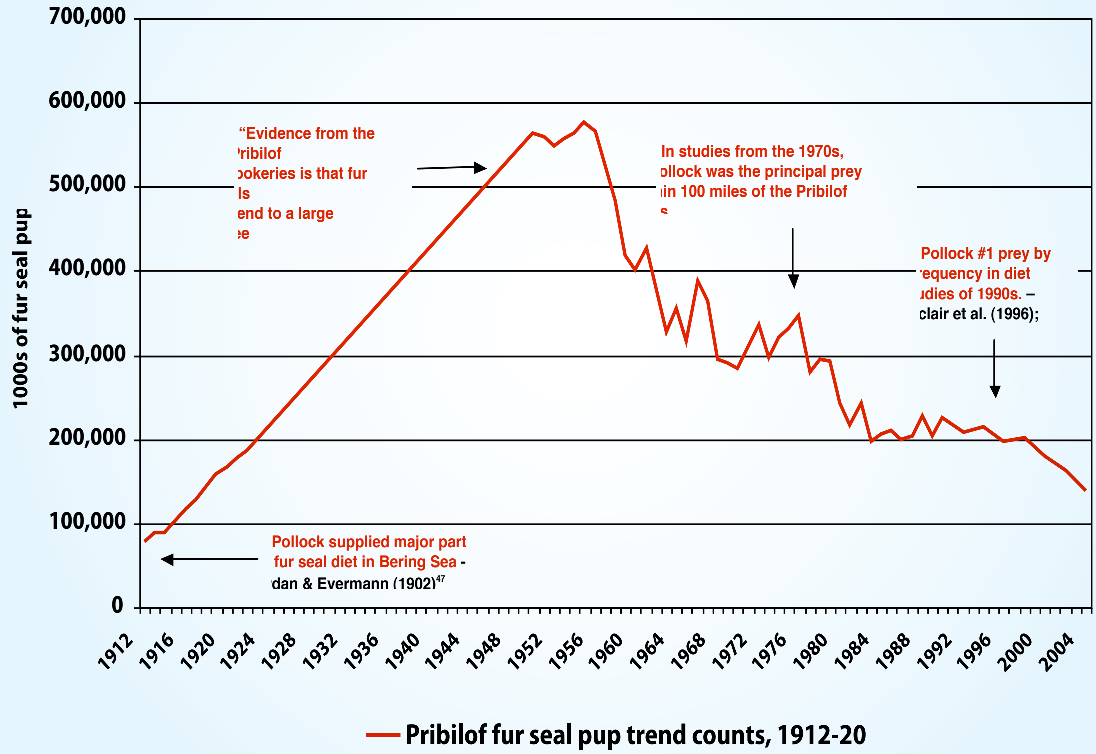
FIGURE 17. DECLINES IN NORTHERN FUR SEALS AND STELLER SEA LIONS IN WESTERN ALASKA, 1960–2004



SOURCE: NMML, NMFS.

The Steller sea lion crash and the accompanying declines of fur seals (illustrated in Figure 18), harbor seals, and some of the largest nesting colonies of fish-eating seabirds in the world are indicators of a major change in the structure of the ecosystem in recent decades.[45] It would appear that the ecosystem carrying capacity has collapsed for these species — that is, for some reason food supplies are limited or reduced and the ecosystem cannot support top predator populations at the levels observed prior to the 1970s and 1980s. But there is no evidence of decline in the productivity of the North Pacific. Indeed, massive factory fisheries have flourished since the 1970s in areas that supported vast numbers of all these species historically.

FIGURE 18. CARRYING CAPACITY OF BERING SEA IN FIRST VERSUS SECOND HALVES OF TWENTIETH CENTURY



SOURCE: NMML, NMFS.

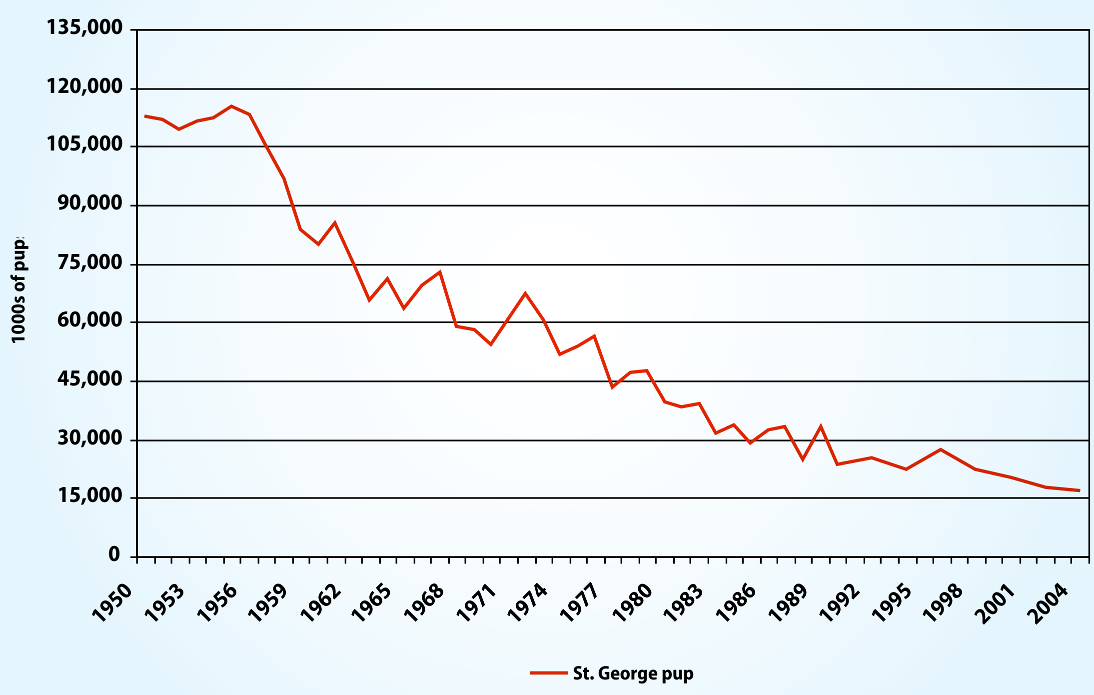
The potential for conflict between large-scale commercial fisheries for pollock and large populations of pollock predators in the North Pacific was recognized more than twenty years ago in the final Environmental Impact Statement for the Bering Sea/Aleutian Islands FMP, and was deemed "especially acute with respect to the more than 2 million pinnipeds that inhabit the Bering Sea and Aleutians, particularly the northern sea lion and the northern fur seal."[51] A 1982 report to the NPFMC cited large increases in catches of Bering Sea pollock and other groundfish from a mere 12,500 tons in the early 1950s to over 2.2 *million* tons in the early 1970s. The report specifically noted that large-scale groundfish fishery removals may reduce the carrying capacity for competing top predators such as the Steller sea lion.[52]

Sea lion and fur seal physiology, reproductive biology, and foraging ecology are energetically expensive and vulnerable to shortages in prey availability. Unlike true seals in the family of *Phocidae*, which build up large stores of insulating blubber and can withstand longer periods of fasting by living off the stored energy, sea lions and fur seals in the family *Otariidae* are considered rather lean animals (with a low percentage of body fat) even in the best of times. The relative leanness of sea lions and fur seals compared to phocid seals has implications for the energetic costs of thermoregulation, foraging, and reproduction. Sea lions and fur seals live particularly close to the edge in this respect, since they need more or less constant supplies of food to maintain proper body condition.[53,54] Energy expenditures during foraging are generally higher than for phocid seals and reflect an "energy maximizer" strategy, requiring the expenditure of large amounts of energy with the prospect of gaining large quantities of food energy in return for the effort.[55] Ready access to food supplies in the vicinity of sites where they haul out to rest, socialize, and care for dependent pups is critical to their survival.

While science can neither prove nor disprove that factory fisheries are outcompeting top predators or undermining the ecological balance in the North Pacific, mainstays in the sea lion and fur seal diet such as walleye pollock, Atka mackerel, and Pacific cod have become the targets of rapidly expanding groundfish fisheries pioneered by Japanese and Russian factory trawlers in the 1960s in areas where these pinnipeds were historically abundant. The National Research Council concluded on the basis of the temporal and geographic pattern of the fisheries that fishery effects on sea lion prey availability are the only causal factor that has a high likelihood of involvement in sea lion declines in western Alaska since 1980.[56] This concern has been the basis of efforts since 1991 to constrain pollock trawling in nearshore waters around major sea lion terrestrial breeding and resting sites, though overall catch from designated critical habitat foraging areas remains high today.

Fishing effort displaced by Steller sea lion protection measures may also contribute to increasing competitive interaction with foraging fur seals in the vicinity of the Pribilof Islands. According to NMFS, the proportion of the total June through October pollock catch taken in fur seal foraging habitat (defined as the combined home ranges of females from the Pribilofs) increased from an average of 40% between 1995–1998 to 69% from 1999–2000, and catch rates were consistently higher in areas of the southeastern Bering Sea used by foraging females from St. George Island.[57] An average of 66–75% of the total annual catch has been taken in this region of the southeastern Bering Sea since the 1970s, even though only approximately 25–33% of the estimated pollock biomass in the Bering Sea is found in this region in the summer groundfish resource surveys.[58,59] While fur seal trends have been declining anomalously throughout the Pribilof Islands for several decades, the population on St. George has suffered the steepest decline over time, rivaling the sea lion decline in magnitude.

FIGURE 19. DECLINING NORTHERN FUR SEAL PUP TRENDS ON ST. GEORGE, PRIBILOF ISLANDS, 1950–2004

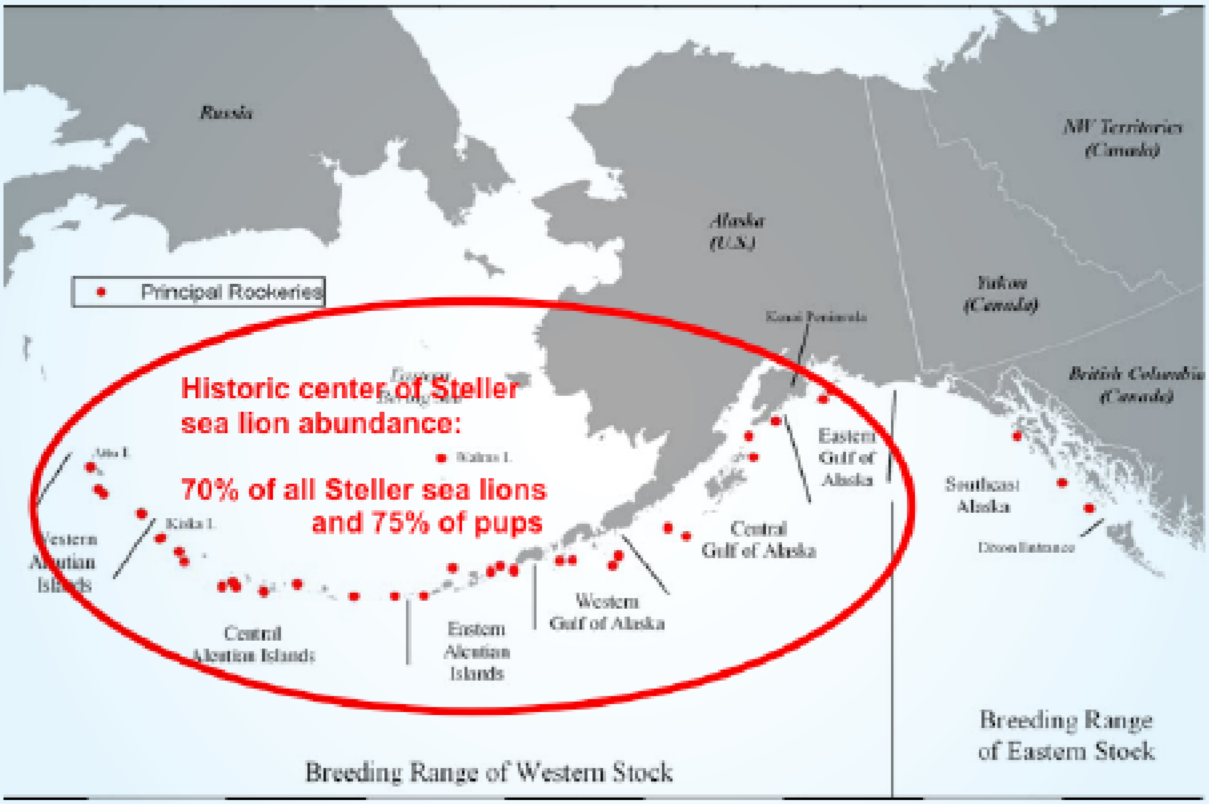


SOURCE: NMML, NMFS.

STELLER SEA LIONS: A CASE STUDY IN FISHERY COMPETITION

Following at least two decades of accelerating decline across the center of its range in southwestern Alaska and decades of decline to low numbers along the west coast of North America and east coast of Russia, the Steller sea lion was listed as threatened across its U.S. range under the Endangered Species Act in 1990.

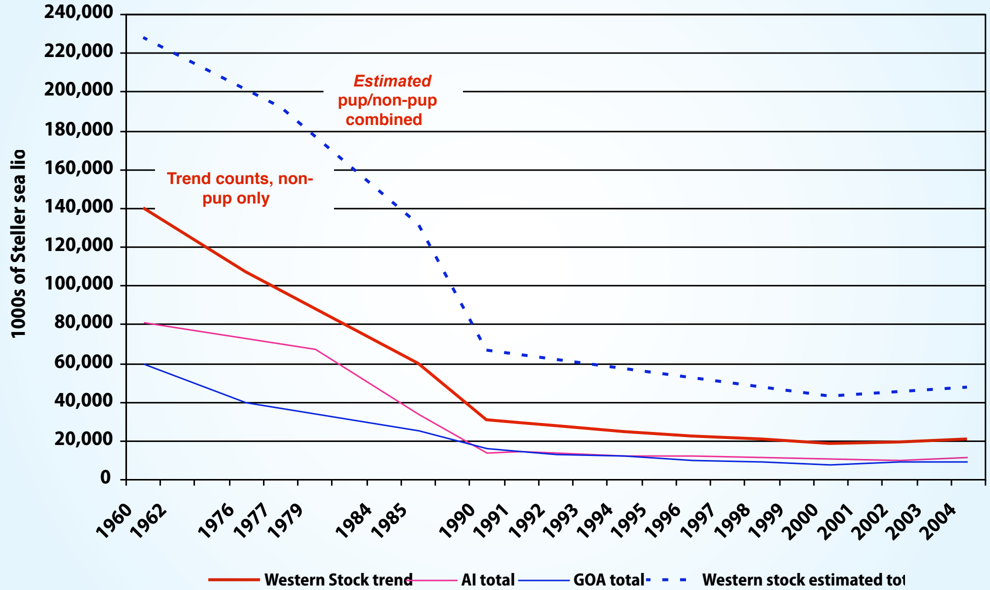
FIGURE 20. BREEDING RANGE OF STELLER SEA LIONS IN ALASKA



SOURCE: Lowell W. Fritz and Charles Stinchcomb, *Aerial, Ship and Land-Based Surveys of Steller Sea Lions (*Eumetopias jubatus*) in the Western Stock of Alaska, June and July 2003 and 2004*, NOAA Technical Memorandum NMFS-AFSC-153 (Juneau, Alaska: U.S. Department of Commerce, NOAA, NMFS, AFSC, 2005).

A great puzzle is why the Steller sea lion decline in western Alaska radiated outward from the major population centers, since there is no evidence of pandemic disease. The expected population response of an endangered species is to contract inward to the center of its geographical range, where conditions are presumably most favorable and support the greatest numbers.[60] Yet a review of the patterns of range contraction for 245 endangered species around the world found numerous examples of apparent exceptions to the ecological rule of thumb, associated with the "contagion-like" spread of human disturbance and habitat destruction.[61] To a large extent, the pattern of the decline of Steller sea lions in western Alaska parallels the spreading impacts of the big factory fisheries that were introduced to the region beginning in the 1960s.

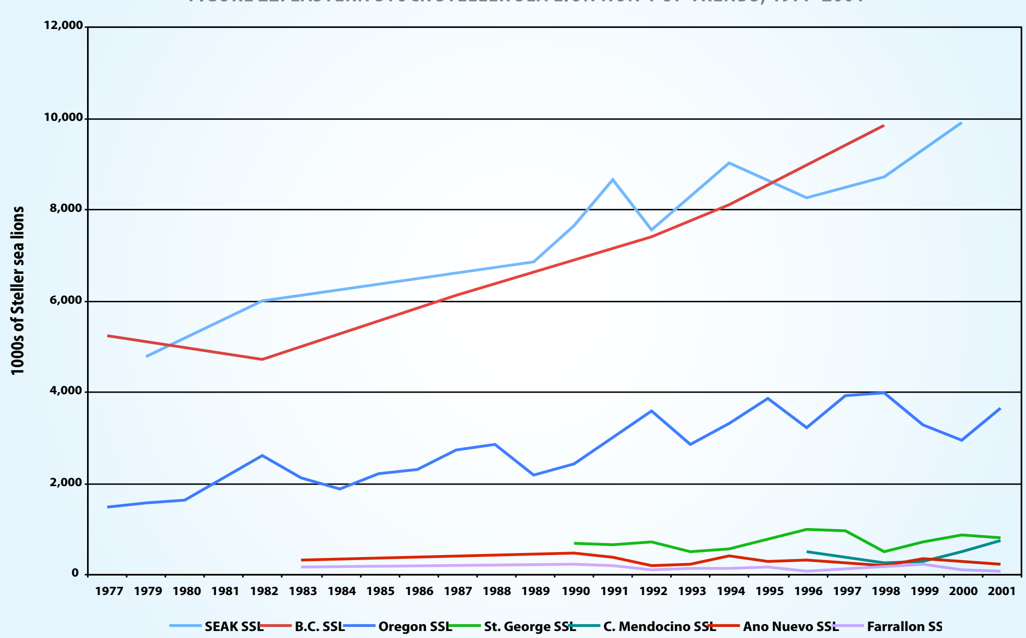
FIGURE 21. WESTERN STOCK STELLER SEA LION NON-PUP TRENDS AND ESTIMATED TOTAL POPULATION TREND, 1960–2004



SOURCE: NMML, NMFS.

By contrast, the threatened eastern stock has increased slowly but steadily over the same time period in southeast Alaska, British Columbia, and parts of the U.S. West Coast, with the most robust growth in southeast Alaska and British Columbia, where there are no large trawl fisheries (see Figure 22).

FIGURE 22. EASTERN STOCK STELLER SEA LION NON-PUP TRENDS, 1977-2001



SOURCE: NMML, NMFS.

Evidence from past research suggests that major causes of the original decline in western Alaska (1970s and 1980s) were low juvenile survival and decreasing birthrates linked to nutritional stress,[62,63,64] in addition to a short-lived commercial culling program in the 1960s. Factors such as disease, predation by killer whales, shooting, Native Alaskan subsistence harvest, or incidental mortality in fishing gear do not appear to explain the decline, although high levels of entanglement mortality in trawl gear contributed significantly to the earlier phases of decline.[65] Food limitation remains a leading hypothesis to explain the present trends and the failure of sea lions to rebound at low population levels.

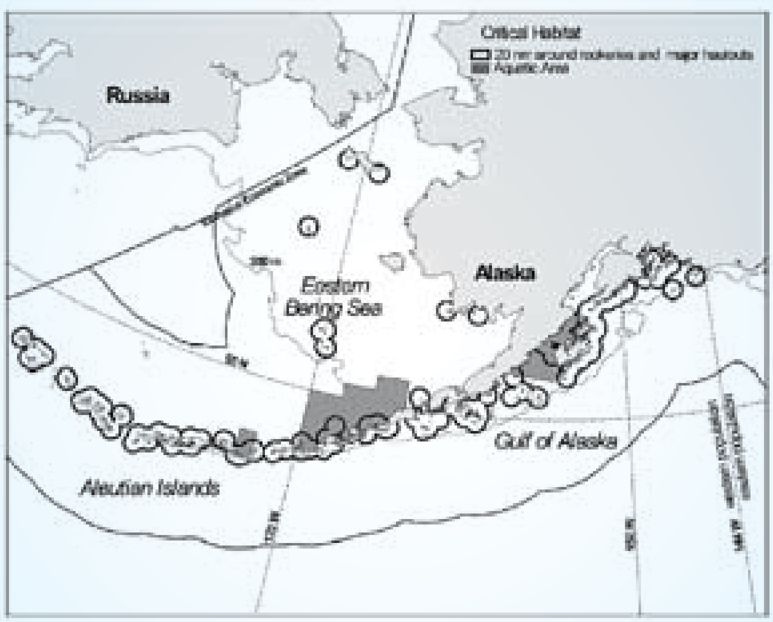
1990–1997

The listing of Steller sea lions as threatened under the Endangered Species Act in 1990 was followed by a succession of management actions under the ESA, as well as fishery management measures closing pollock fishing grounds in the Aleutian Basin and central Bering Sea following steep declines in pollock biomass:

- 1990: Steller sea lions listed as threatened under the Endangered Species Act.
- 1991–1993: Rookery trawl exclusion zones established 0–10 nautical miles around 36 rookeries.
- 1992: Closure of the Bogoslof District to directed pollock fishing as part of the international Convention on the Conservation of the Pollock Resources of the Central Bering Sea ("Donut Hole" Treaty).[66]
- 1993: Designation of critical habitat as required by the Endangered Species Act.[67]
- 1997: Uplisting of western stock of Steller sea lions (areas west of longitude 144° west) to endangered status under the ESA.

The designation of critical habitat in 1993 included 20-nautical-mile zones around rookeries and major haul-outs in western Alaska, as well as three large aquatic foraging areas (seen in Figure 23).

FIGURE 23. CRITICAL HABITAT FOR THE WESTERN POPULATION OF STELLER SEA LIONS



SOURCE: NMFS (1993).

In this designation, NMFS noted that waters in the vicinity of these terrestrial sites are particularly important foraging zones for post-parturient females and young animals, based on historical ship-based observations and limited telemetry tracking data for this species.[68] At the same time, NMFS noted that Steller sea lions regularly

Steller sea lions, Unalaska Island, Alaska © 2006 Dan Parett.

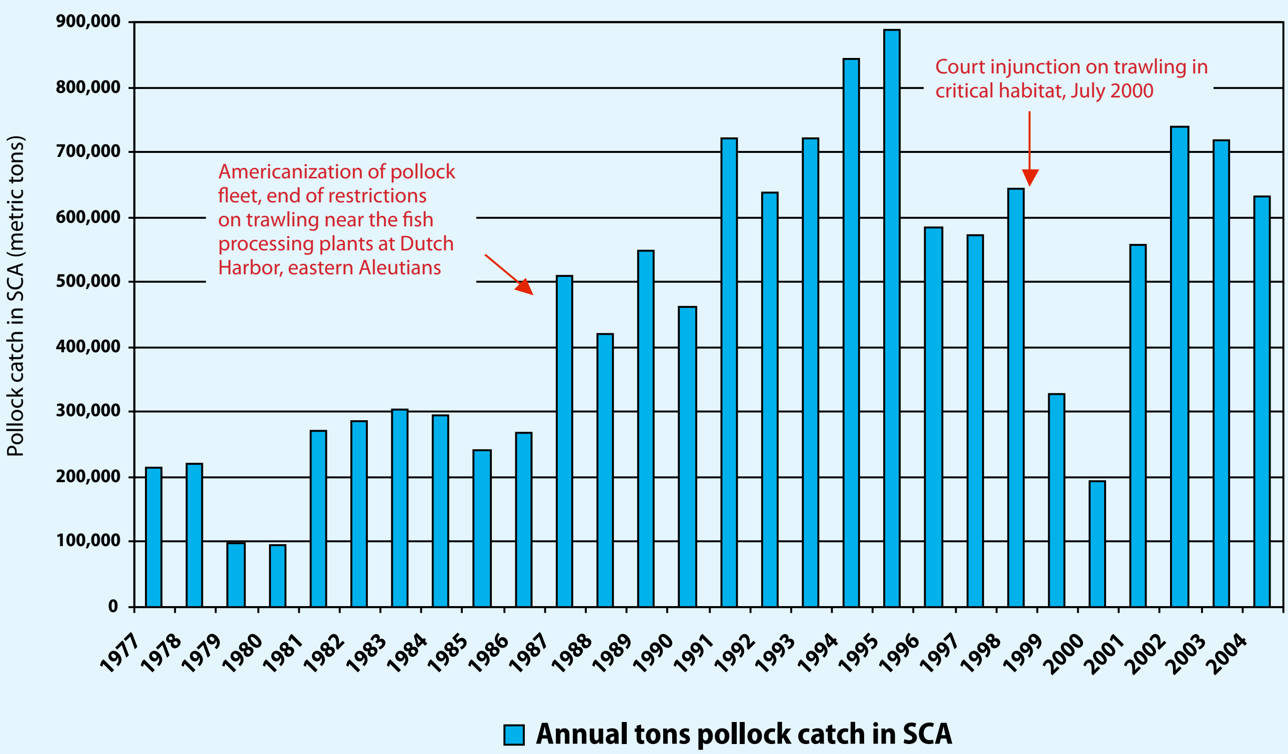
forage much farther offshore than 20 nm, especially in the fall, winter, and early-spring months. Thus, in addition to the 20-nm zones around rookeries and haul-outs, NMFS designated three large aquatic foraging zones in the Gulf of Alaska (Shelikof Strait), the eastern Aleutian Islands (longitude 164–170ºW), and central Aleutian Islands (Seguam Pass). These areas were chosen based on their importance as prey habitat and sea lion foraging areas, as centers of large Steller sea lion populations 30 years ago, and as focal points for major trawl fisheries since the early 1970s.[69]

In 1991, the NMFS Protected Resources Division recommended special management measures to prohibit trawling within 10 nm of 37 major rookeries in western Alaska because: (1) trawl fisheries account for the majority of the catch of species of concern in critical habitat; (2) trawlers have higher bycatch of non-target prey species, any number of which may serve as important seasonal or secondary items in the sea lion diet; (3) trawlers are the primary source of lethal incidental entanglements in nets; and (4) trawlers are responsible for benthic habitat disturbances and changes in species composition. NMFS acknowledged serious inadequacies of the 10 nm rookery trawl exclusion zones at the time they were proposed,[70] and, in fact, the sea lion population in western Alaska (but not southeast Alaska or British Columbia) continued to decline throughout the 1990s.

At the same time, the pollock fisheries became increasingly physically concentrated in designated Steller sea lion critical habitat and temporally concentrated in two large pulses during January–March (the roe fishery on spawning grounds) and September–November. By the mid-1990s, as much as 70% of the entire annual Bering Sea pollock catch was taken inside the boundaries of the large aquatic foraging zone off the eastern Aleutian Islands, known today as the Sea lion Conservation Area (SCA). In the Gulf of Alaska and Aleutian Islands, the percentage of the pollock catch in critical sea lion habitat has ranged from 50–90%, averaging over 70% in the Gulf of Alaska since the 1980s. The Gulf pollock fishery is also temporally concentrated in winter (on spawning grounds) and late summer/early fall, despite nominal trimester or quarterly seasonal allocations since the early 1990s.

The sharp increase of catch in the southeastern Bering Sea critical habitat foraging area was partly the result of overfishing in the central Bering Sea (Donut Hole) and U.S. waters of the Aleutian Basin and Aleutian Islands in the late-1980s and early 1990s. Following the closure of the international waters of the Donut Hole and U.S. waters of the Bogoslof District (Area 518) after 1991, and in the absence of any spatial or temporal management regulations, pollock fishing effort shifted eastward toward the shelf. A massive winter roe fishery developed on the large pollock spawning grounds off the eastern Aleutian Islands, conveniently located near the large fish processing plants at Dutch Harbor and Akutan — all within the boundaries of the SCA (see Figure 24).

FIGURE 24. HISTORY OF POLLOCK CATCH IN SOUTHEASTERN BERING SEA SEA LION CONSERVATION AREA (SCA), 1977–2004

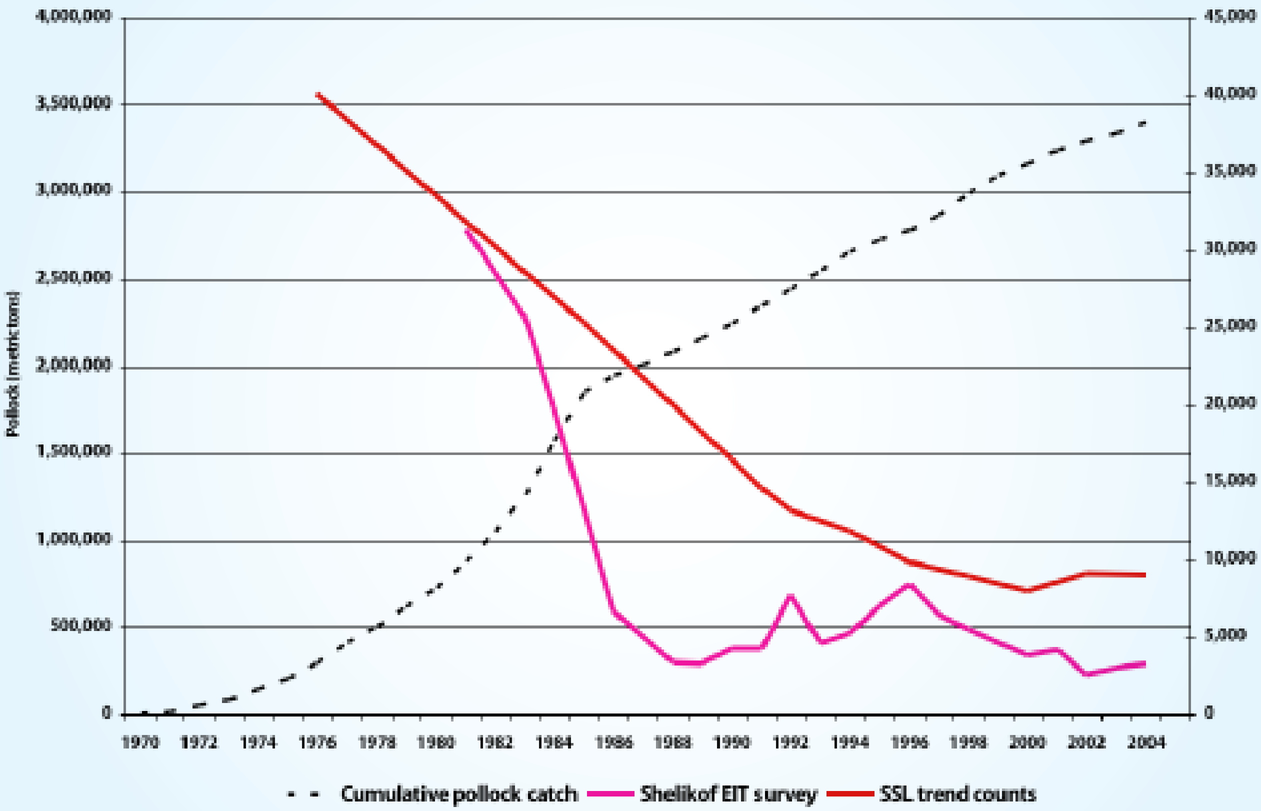


SOURCE: NMML, NMFS.

This spawning assemblage was hardly fished prior to 1986,[71] a fact explained by the existence of what was then called the Winter Halibut Savings Area, closed to foreign trawlers from January–May, and the adjacent Bristol Bay Crab Pot Sanctuary, closed to all trawling year-round. The analytical documentation for an amendment to extend the inshore/offshore pollock allocation in the Bering Sea[72] highlighted the dramatic growth in the January–March roe pollock fishery and its concentration in the pelagic foraging habitat of the Sea lion Conservation Area between Unimak Island and Islands of the Four Mountains. Pollock catches from this area in the winter spawning season increased to over half a million tons by the mid-1990s.[73]

This area of the eastern Aleutian Islands was once the epicenter of the Steller sea lion population in western Alaska, estimated to support greater than 50,000 sea lions in the late 1950s and early 1960s.[74] Since the 1990s, the biennial population trend counts of non-pup sea lions in this area have hovered around 5,000–6,000 animals — approximately 90% fewer than in the pre-fishery era.

FIGURE 25. CUMULATIVE GULF OF ALASKA POLLOCK CATCH, SHELIKOF POLLOCK BIOMASS TRENDS, AND REGIONAL STELLER SEA LION NON-PUP TRENDS, 1970–2004



SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska (2005)

The 2004 Bering Sea pollock catch in sea lion critical habitat (concentrated in the SCA) theoretically could have fed 43,943 Steller sea lions for one year (22,102 lactating females, 21,841 males), based on conservative assumptions about average size of sea lions and daily feeding rate. Not all of these pollock would have been eaten by sea lions in the absence of the fishery, but over 50,000 sea lions occupied that region of the eastern Aleutians in the pre-fishery years, and they would have required an enormous quantity of forage. It is difficult to avoid the conclusion that factory fisheries for pollock and other groundfish have reduced the carrying capacity for sea lions in this region by out-competing and replacing them as the top finfish predator.

A similar trend in the west-central Gulf of Alaska sea lion population parallels the rapid development of the Gulf pollock fishery in the late 1970s, which peaked in the early 1980s during the heyday of the Shelikof Strait roe pollock fishery, after which time the pollock stock crashed along with sea lion numbers. Neither the sea lion population nor the pollock stock have recovered, though the fishery continues to operate without interruption at lower TAC levels.

This type of evidence, while not conclusive proof of cause and effect, led the National Research Council to conclude, on the basis of the temporal and geographic pattern of the fisheries, that fishery effects on sea lion prey availability are the only causal factor considered to have a high likelihood of involvement in sea lion declines in western Alaska since 1980.[75] More recently, Hennen concluded that high levels of fishing activity in the vicinity of Steller sea lion rookeries likely had a negative effect on sea lion population trends from the late 1970s to the early 1990s, and that the adoption of fishing regulations to protect sea lions since the early 1990s (such as rookery trawl exclusion zones) has reduced this effect.[76]

1998–2000

In April 1998, Greenpeace, American Oceans Campaign (now Oceana), and Sierra Club Alaska sued NMFS under the Endangered Species Act (*Greenpeace v. NMFS*) for failure to address the fundamental contradiction between a fisheries management system that allows large-scale groundfish fisheries to concentrate their catch in Steller sea lion critical habitat, on one hand, and the legal obligation to ensure the food supplies of protected species, on the other. Plaintiffs also emphasized that NMFS failed to address the cumulative, ecosystem-scale effects of employing a single-species fishing strategy based on MSY (which reduces the biomass of North Pacific groundfish stocks 60% or more on average, by design), on sea lion carrying capacity.

In December 1998, NMFS completed a detailed consultation and biological opinion on the BS/AI Atka mackerel fishery and the BS/AI and GOA pollock fisheries. That opinion concluded that the Alaska pollock fisheries were likely to jeopardize the continued existence of the endangered western population of Steller sea lions and adversely modify designated critical habitat, based on concerns about spatially and temporally concentrated pollock fishing, the likelihood of causing localized depletions of sea lion prey, and other associated effects of prey competition.[77]

The Endangered Species Act requires a reasonable and prudent alternative (RPA) to avoid the source of jeopardy and/or adverse modification of critical habitat. The intent of the resulting 1999–2000 pollock mitigation plan was three-fold: (1) protect waters in the vicinity of sea lion rookeries and haul-outs, (2) spatially disperse the fishery across more of the pollock range, especially in the eastern Bering Sea, and (3) temporally disperse the fishery throughout more of the year.[78,79] The RPA plan included the following mitigation measures to address jeopardy and adverse modification:

- Prohibition on trawling for pollock within 10 or 20 nm of 52 haul-out sites in the Bering Sea and Gulf of Alaska. As a result, the total area affected by Steller sea lion trawl closures after the January 1999 emergency rule was 48,920 km^2 (13% critical habitat closed to all trawling around rookeries since 1993), plus the additional area closed to pollock fishing around haul-out sites (43,170 km^2, 11% critical habitat). Those rookery and haul-out closures represented 24% of the critical habitat designated for the western stock of Steller sea lions.[80]
- Restrictions on pollock fishing in the large southeastern Bering Sea aquatic foraging area (renamed the Sea lion Conservation Area). Restrictions on pollock fishing in that area reduced catches to approximately 388,000 tons in 1999, compared to a potential 773,000 tons in the absence of such regulation. In 2000, revised RPAs further limited the catch to 297,000 tons.
- Closure of the entire Aleutian Islands management area to pollock fishing. The NPFMC imposed a pollock fishing moratorium in the Aleutian Islands in 1998, due to low pollock biomass and high uncertainty. The amount of foregone catch in the pollock fishery was small, however, since only 2% of the total BS/AI TAC allowance was affected. Nevertheless, the area extends over hundreds of miles, encompassing 21% (83,080 km^2) of sea lion critical habitat.
- Temporal dispersal of the Bering Sea pollock TAC into two fishing seasons outside sea lion critical habitat (status quo) but four (instead of two) fishing seasons for the portion of the pollock fishery permitted within the SCA, as well as four (instead of three) fishing seasons in the Gulf of Alaska pollock fishery.
- Spatial dispersal of the Bering Sea pollock TAC into at least three management areas, including areas east and west of the 170° west longitude line outside the SCA.[81]

CHANGES TO THE BERING SEA POLLOCK FISHERY UNDER THE AMERICAN FISHERIES ACT (AFA) OF 1998

Changes to the 1999 Bering Sea pollock fishery, implemented under the terms of the American Fisheries Act of 1998, paralleled the implementation of the pollock RPA measures. Measures adopted under the AFA agreement included:

- Closure of the Bering Sea pollock fishery to new entrants and allocation of the pollock TAC by sectors within the remaining fleet.
- Reduction of the number of active vessels in the Bering Sea catcher/processor fleet by retiring nine factory trawlers from the fishery.
- Creation of offshore fishing cooperatives in 1999 and shore-based cooperatives in 2000, eliminating the derby-style race for pollock.

TABLE 25. POLLOCK MANAGEMENT MEASURES AFFECTING STELLER SEA LION CRITICAL HABITAT, 1991–2000

Year	Management measure	Area critical habitat	% Critical habitat (CH)	% EEZ
1993	**Designation of CH**	**386,770 km^2**	**100%**	**12%**
Pre-pollock management actions				
1991–1993	Closure within10 or 20 nm radius of 37 rookeries to all trawling year-round	48,920 km^2	13%	1.5%
1993	Closure of Bogoslof (Area 518) to directed pollock fishing	35,180 km^2	9%	1.1%
1991–1993	Total Steller sea lion CH closed to all trawling or pollock trawling	84,100 km^2	22%	2.6%
Post-pollock RPA (additive to pre-RPA measures)				
1999–2000	Closure to pollock fishing within 10 or 20 nm of 75 haul-outs seasonally or year-round	43,170 km^2	11%	1.3%
1999–2000	Aleutian Islands pollock fishery closure	83,080 km^2	21%	2.6%
1999–2000	Total Steller sea lion CH "protected" during some portion of the year	210,350 km^2	54%	6.5%

SOURCE: NMFS, *Endangered Species Act Section 7 Consultation - Biological Opinion and Incidental Take Statement* (Juneau: NMFS, 2000),160.

As noted in the "Revised Final Reasonable and Prudent Alternatives for Pollock Fisheries in the BS/AI and GOA,"[82] the AFA offers potential mechanisms for slowing the pace of pollock fishing within a season, as indicated by lower daily catch rates for the catcher-processors and Community Development Quota (CDQ) sectors in the offshore fishing cooperatives during 1999. However, a comparison of the 1998 Bering Sea pollock fishery with the 1999 fishery indicated that the realized temporal dispersion was limited and that fishing continued to be temporally concentrated. This is, in part, because the January–March roe fishery has a limited span of time in which egg-bearing pollock are available and the roe is considered suitable for market. Thus, the level of pollock trawling in the SCA during the January–March period of 1999–2000 under the pollock RPA emergency regulations was still approximately six times higher than total pollock catches from this region in the first quarter of the year during the early 1980s, as only trace amounts of pollock fishing occurred on this spawning aggregation prior to 1986.[83,84]

2000–2001

On July 19, 2000, the U.S. District Court in Seattle granted injunctive relief to Greenpeace and co-plaintiffs and prohibited all groundfish trawling off southwestern Alaska (west of longitude 144° west) within Steller sea lion critical habitat, pending an adequate analysis of the fishery impacts:

> *Despite these protective measures, a considerable amount of critical habitat remains open to fishing. Most year-round all-trawl exclusion zones extend out to only 10 nautical miles. Most other exclusion zones are seasonal and restrict only specific fisheries. Other fisheries are not restricted at all. In the Bering Sea/Aleutian Islands fisheries, over 350,000 metric tons of pollock, 79,000 metric tons of Pacific cod, and 29,000 metric tons of Atka mackerel were caught within critical habitat in 1999. These figures demonstrate that a significant percentage of the annual catch occurs in critical habitat (36%, 50%, and 52%, respectively). Although the overall tonnage taken in the Gulf of Alaska fisheries for these fish species in 1999 was less than in the Bering Sea, with the exception of mackerel, the figures in the Gulf of Alaska represent a greater percentage of the annual catch (83%, 61%, and 34% respectively).*[85]

The court found NMFS's defense unconvincing without an adequate programmatic biological opinion that evaluated the impacts of the policies and regulations of the fishery management plans *as a whole*, not only individual fisheries considered in isolation:

> *[O]ne of the major issues that NMFS has failed to properly analyze is the combined, overall effects these fisheries may have on sea lions. In none of its current biological opinions does NMFS explain how the various groundfish fisheries and fishery management measures interrelate and how the overall management regime may or may not affect Steller sea lion survival and recovery. Each individual fishery does not occur in a vacuum. Thus, conclusions with respect to a single fishery are insufficient to insure that the combined effects do not cause jeopardy or threaten harm*.[86]

With the release of the court-ordered programmatic biological opinion and analysis of the groundfish fishery management plans in November 2000 (the FMP BiOp), NMFS concluded that it is reasonably likely that fishery competition poses a threat to Steller sea lions at three major spatial-temporal scales of interaction: global, regional, and local.[87] The fisheries effects that led NMFS to this conclusion occur cumulatively over time, as well as regionally and locally on shorter time scales,[88] and can reduce the carrying capacity of critical habitat.[89] Thus the goal of any acceptable RPA mitigation plan should be to design an RPA highly likely to avoid competition with Steller sea lions "at all three scales where the competitive interactions occur."[90]

With this consultation, the NMFS concluded that the groundfish fisheries as a whole jeopardize Steller sea lions and adversely modify sea lion critical habitat, requiring new and more comprehensive RPA regulations to address the impacts of the pollock, Atka mackerel, and Pacific cod fisheries. Significantly, NMFS also explicitly acknowledged for the first time that the proxy-MSY "harvest policy" ($F_{40\%}$) has reduced important Steller sea lion prey stocks to 40–60% of the expected unfished stock size over time, *by design*. The estimated 40–60% decline in exploited groundfish biomass resulting from the $F_{40\%}$ harvest policy is "reasonably likely to reduce significantly" the prey base for Steller sea lions over time and to reduce the carrying capacity of sea lion critical habitat.[91,92]

The FMP BiOp's reasonable and prudent alternative mitigation measures included four basic elements:

- Complete closure of two-thirds of sea lion critical habitat to fishing for pollock, Pacific cod, and Atka mackerel, including an "experimental design" of treatment and control areas to assess the relative impacts of fished and unfished environments.
- Strict seasonal catch limits in open areas of critical habitat to disperse fishery catches spatially in proportion to biomass distribution, reducing pollock catches in critical habitat compared to 1998 from approximately 80% to 42% in the Gulf of Alaska and from approximately 45% to 14% in the Bering Sea.
- A system of four seasons inside and two seasons outside critical habitat to disperse the fisheries temporally and further reduce the likelihood of causing localized depletions of the prey field in critical habitat.
- A "global control rule" to address the cumulative impacts of the fishing rate (the $F_{40\%}$ "harvest policy" of the FMPs), but only when stock biomass falls below the $B_{40\%}$ spawning stock "target" level, including a minimum stock-size threshold of $B_{20\%}$.

Significantly, the FMP BiOp did *not* consider reductions in catch levels in order to leave more prey in the water and prevent displaced fishing effort from adversely affecting other species. The "global control rule" does not entail TAC reductions of any sort under the conventional fishery control rules until the stock biomass has decreased more than 60% from the estimated unfished stock size, and even then the reduction in the fishing mortality rate is minimal unless the stock biomass falls below $B_{20\%}$ (i.e., a more than 80% decrease from unfished stock size).

U.S. Senator Ted Stevens (R-Alaska) blocked implementation of the reasonable and prudent alternative measures, scheduled to go into effect in 2001, by a legislative rider to Senate appropriations legislation in December 2000. Under the terms of this rider, Congress did not waive the application of the ESA to the groundfish fisheries. However, the fisheries were to operate under emergency RPA rules based on 1999–2000 revised pollock RPA regulations during 2001, with the understanding that the full suite of RPA measures would be implemented in 2002 unless alternative mitigation measures were agreed upon before then. This proviso invited NMFS to reopen the consultation process and develop an alternative plan that was acceptable to affected fishing interests. Seizing the initiative, in January 2001 the NPFMC appointed a handpicked "RPA Committee," comprised predominantly of industry stakeholders in the fisheries, and tasked them to come up with an alternative mitigation plan.

The RPA Committee consisted of eleven representatives from the fishing industry, six representatives from federal and state agencies, three representatives from environmental organizations, and one representative from the University of Alaska.[93] NMFS presented minimum standards for an adequate RPA as a "jeopardy bar," but the interests of the endangered species were secondary to efforts to satisfy the economic stakeholders on the committee.[94] The RPA Committee negotiated a "protection" plan of such complex detail, based on each individual fishery stakeholder's favorite fishing grounds, that NMFS concluded it was impossible to easily sum these various closures and determine how much Steller sea lion critical habitat is actually "protected" (i.e., closed to fishing):

> *This action, which represents more of a mosaic, is best described (for closure areas) by looking at each individual fishery and area to determine what is actually closed and open inside Steller sea lion critical habitat…An area closed to pollock fishing may be open to Pacific cod fishing, or Atka mackerel. Thus, closure areas are not exactly equal.*[95]

In the 2001 biological opinion (RPA BiOp), NMFS signed off on the RPA Committee's conclusion that areas within 10 nm of rookeries and major haul-outs were three times more important than areas beyond 10 nm,[96] based on a dubious interpretation of new telemetry tracking data for young (6–24 months) sea lions. Though this "zonal" approach to critical habitat was purportedly based on the greater importance of nearshore habitat to foraging sea lions, it provided NMFS a rationale and pretext for repealing the temporal, spatial, and catch limit provisions of previous RPAs that protected critical habitat beyond 10 nautical miles from shore:

- Spatial dispersion beyond 10 nm is now considered to be a low priority given the frequency of telemetry locations beyond 10 nm.[97]
- Temporal dispersion beyond 10 nm is now considered to be a low priority given the frequency of telemetry locations beyond 10 nm.[98]
- Catch limits within critical habitat areas beyond 10 nm "that were previously considered to be integral to the RPA in the FMP biological opinion" are now considered unnecessary.[99]

This approach did not address the global-scale effect of fishing down the groundfish stocks under the $F_{40\%}$ "harvest policy," which NMFS identified as a component of jeopardy and adverse modification in the 2000 FMP BiOp.

Overall, the NPFMC-brokered plan restored most elements of the pre-RPA management regime:

- Two-season A-B pollock fishery restored in all areas of Bering Sea, including the SCA off the eastern Aleutian Islands.
- No pollock catch limit in the SCA after April 1.
- Only 39% of the SCA foraging habitat zone closed to pollock trawling.
- 40% of Bering Sea pollock TAC continues to be taken in January–March roe fishery on spawning grounds, and as much as 70% of that quota may be taken in the SCA.
- A maximum limit (=70% of A-season pollock quota) can be taken from the SCA before April 1 — i.e., comparable to the levels of the 1990s.
- No further spatial dispersion of catch in Bering Sea subareas.
- No catch limits in critical habitat in the Gulf of Alaska.
- Despite "four-season" apportionment of Gulf of Alaska pollock TAC, 50% of A-B-season TAC is concentrated in the January–March roe fishery on spawning grounds.
- "Global control rule" retained as minimum stock size threshold (20% of theoretical unfished stock size for pollock, cod, and Atka mackerel) but does not entail TAC reductions under the conventional fishery control rules until the stock biomass has decreased more than 60% from the estimated unfished stock size, and the reduction in the fishing rate is minimal unless the stock biomass falls below $B_{20\%}$ (i.e., more than 80% decrease from unfished stock size).

The consequences of the RPA Committee's interpretation of the data for critical habitat protection and the resulting complexity of this fishery-by-fishery negotiation can be seen in the court-ordered June 2003 biological opinion supplement. This document estimated critical habitat "protected" for each individual fishery and gear type, but the areas closed to one fishery or one gear type within a fishery do not amount to a total estimate of critical habitat. Overall, for all regions combined, 70% of critical habitat is closed to pollock trawlers (see Table 26).

TABLE 26. AREA OF STELLER SEA LION CRITICAL HABITAT CLOSED BY FISHERY AND GEAR UNDER NPFMC-BROKERED RPA OF 2001									
	Fishery	**Gear**	**0–3 nm**	**3—10 nm**	**0–10 nm**	**10–20 nm**	**Foraging areas**	**Total CH**
% Critical habitat closed by "zone"	Pollock	trawl	100%	90%	91%	69%	39%	70%
	Pacific cod	trawl	100%	73%	76%	36%	39%	48%
		pot	78%	44%	46%	31%	39%	38%
		longline	78%	44%	48%	25%	38%	34%
	Atka mackerel	trawl	100%	83%	85%	66%	48%	66%

SOURCE: NMFS, *Supplement to the Endangered Species Act—Section 7 Consultation Biological Opinion and Incidental Take Statement of October 2001* (2003).

However, the main pollock-fishing ground in the Bering Sea SCA (i.e., foraging area) was not significantly affected by the closures, and unofficial catch data for 2002–2004 indicate that pollock fishing in critical habitat has not been significantly reduced in either the Bering Sea or the Gulf of Alaska. By contrast, 63% of Steller sea lion critical habitat would have been closed to all pollock, cod, and Atka mackerel trawling under the 2000 FMP BiOp's mitigation plan. In neither case would all Steller sea lion critical habitat be protected from all trawling, as proposed by the plaintiffs.

Under court order, NMFS prepared the June 2003 final supplement to the October 2001 RPA BiOp. Although the 2003 supplement was supposed to justify the council-brokered 2001 RPA plan, it cast considerable doubt on the rationale for the 2001 RPA deal. In effect, the levels of trawling in critical habitat that were judged likely to cause jeopardy and adverse modification of habitat in the November 2000 FMP-level BiOp were suddenly said to be acceptable. However, as noted by the Court, the 2001 BiOp was a supplement to the FMP BiOp but does not replace the FMP BiOp, which remains in effect to the present.[100]

In short, NMFS and the NPFMC overcame the Endangered Species Act to placate the powerful pollock industry and other groundfish industry interests.

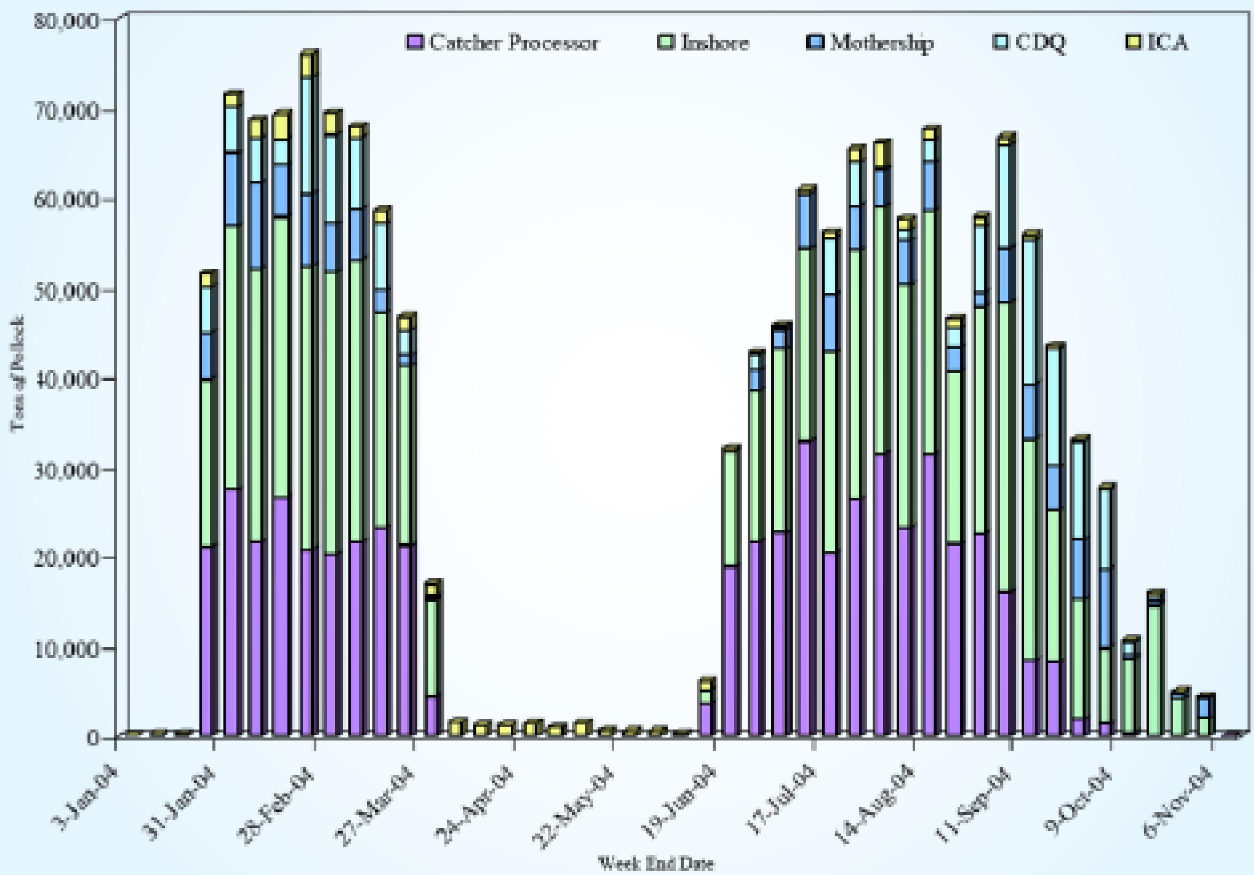
SEASONAL PATTERNS OF CONCENTRATED FISHING IN THE WINTER AND FALL MONTHS HAVE NOT CHANGED APPRECIABLY UNDER THE NPFMC-BROKERED MITIGATION PLAN

As in the past, NMFS identifies winter as a season of particular concern to sea lions. NMFS also underscores the importance of the fall season to juvenile sea lions entering their second year and females nursing new pups.[101] But the analysis in the 2003 BiOp supplement and subsequent inseason management data analysis by NMFS indicate that the temporal pattern of two large pulses of pollock fishing in winter and late summer/mid-autumn continues.[102]

Detailed weekly catch statistics for Bering Sea pollock during 1996–2002 indicated lower weekly catch levels and an extension of the average winter roe fishing season from about 10 to 13 weeks, but there is a limited window of time in the winter A season when pollock roe is available and ripe for market, thus the vast bulk of the A-season catch is taken between January and March, as it was in the 1990s. The earlier start of the B season (July) is the most notable change in seasonal operations, ramping up to peak catch levels by early September and tailing off in October as in the past.

Based on the 2003 BiOp supplement, the 2000–2002 weekly peak catches were about 40% lower in the winter and 25% lower in the fall compared to the 1996–1998 average,[103] but subsequent inseason management data analysis by NMFS illustrates that the overall pattern of two large pulses of fishing has not changed appreciably in the Bering Sea (see Figure 26).

FIGURE 26. 2004 BERING SEA/ALEUTIAN ISLANDS POLLOCK CATCH BY WEEK AND SECTOR



SOURCE: NMFS, *Alaska Region Inseason Management Report for 2004* (2004).

Overall, the EBS pollock fishery takes as much as two months longer to catch the TAC, largely due to the earlier start date of the B season in late June or early July, rather than August or September. The earlier start of the B season may also increase competition with foraging fur seals from the Pribilof Islands rookeries, whose range extends a hundred miles or more in every direction over the continental shelf and slope in the summer and fall months, when hundreds of thousands of female fur seals are trying to feed growing pups.

In the Gulf of Alaska, by contrast, the pollock TAC has been apportioned in three or four seasons since 1990. In theory, the Gulf pollock TAC is evenly divided into four "seasons" at present (see Table 27).

TABLE 27: ALLOCATION OF 2004 GULF OF ALASKA POLLOCK TAC (metric tons) BY SEASON AND MANAGEMENT SUBAREA, BASED ON ESTIMATED STOCK BIOMASS DISTRIBUTION				
Season	Shumagin 610	Chirikof 620	Kodiak 630	Total
A: 20 Jan	3,747	9,027	3,091	15,865
B: 10 Mar	3,748	10,704	1,413	15,865
C: 25 Aug	7,717	3,380	4,768	15,865
D: 1 Oct	7,718	3,379	4,768	15,865
All year:	22,930	26,490	14,040	63,460

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska (2003).

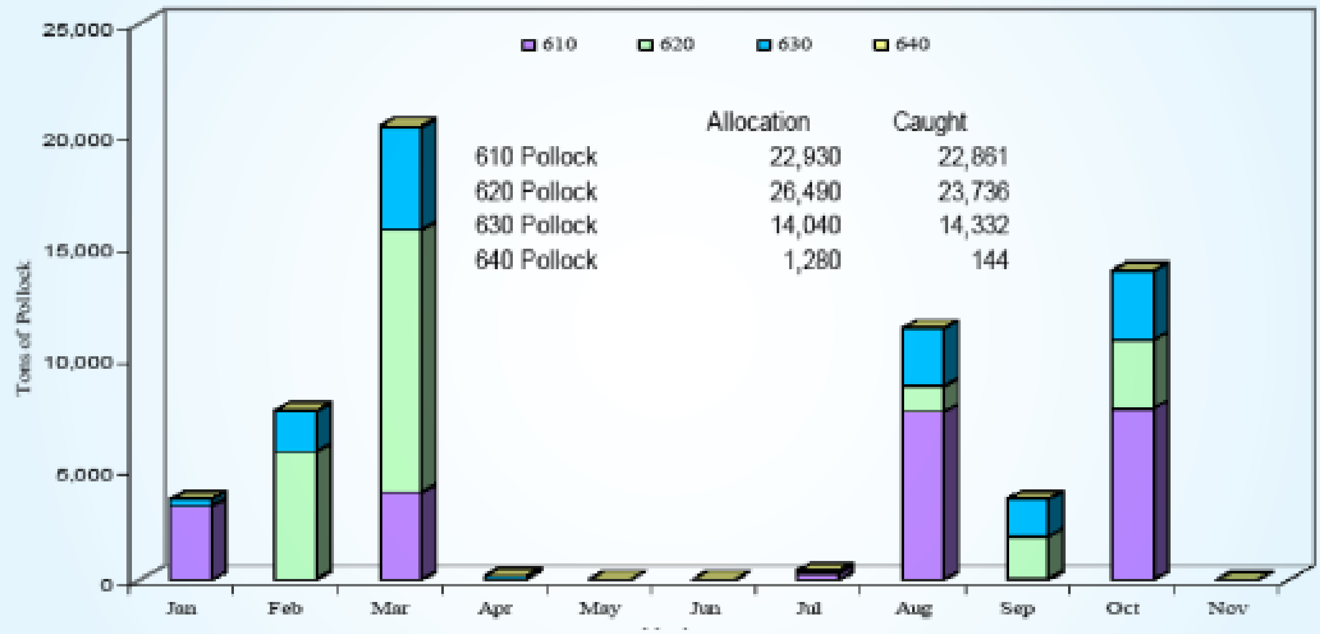
In reality, the "seasons" are defined in such a way that half of the annual TAC is available during the January-March roe season and the other half is available at the end of summer and early fall, as before. Moreover, the over-capitalized Gulf pollock fleet rapidly takes the small seasonal and area TAC apportionments, so that a "season" may last a few days or less in some areas (see Table 28).

TABLE 28. NUMBER OF GULF OF ALASKA POLLOCK DAYS FISHED BY SEASON AND MANAGEMENT SUBAREA, 2004			
Subarea	Season	Days	Total
Shumagin 610	A	2	16
	B	3	
	C	5	
	D	6	
Chirikof 620	A	36	86
	B	11	
	C	8	
	D	31	
Kodiak 630	A	2.5	13.5
	B	1	
	C	8	
	D	2	

SOURCE: NMFS, *Alaska Region Inseason Management Report for 2004* (2004).

The result is that the "four-season" pollock TAC apportionment in the Gulf of Alaska looks a great deal like the two-season approach in the Bering Sea (see Figure 27).

FIGURE 27. 2004 GULF OF ALASKA POLLOCK CATCH AND SEASONS



SOURCE: NMFS, *Alaska Region Inseason Management Report for 2004* (2004).

In the October 2001 RPA BiOp, NMFS recognized that the 10 nm protection zones and virtual lack of limits on overall catches in critical habitat will encourage greater concentration of the pollock, cod, and Atka mackerel fishery catches in critical habitat compared to the protection plan recommended in the November 2000 FMP BiOp:

> *Because there are virtually no limits on catch in critical habitat (the exception is a limit of about 70–75% of each seasonal allowance in the SCA and Atka mackerel harvest limits of 60% in the AI), it is likely that the majority of the harvest will be concentrated in these zones. Previous experience with pollock in the GOA in 1999 and 2000 reminded us that even though most of the 0–10 nm areas of critical habitat were closed, that the overall fraction of the catch in critical habitat remained relatively the same as before [the RPAs].*[104]

As a result, Steller sea lion critical habitat continues to be the focus of large trawl fisheries for pollock, as well as cod and Aleutian Atka mackerel.

The court-ordered 2003 NMFS analysis of fishery patterns pre- and post-2002 indicated that the present RPA fishery mitigation plan has allowed pollock catches in critical habitat to remain high or to rise to formerly high levels that existed prior to the determinations of jeopardy and adverse modification in the 1998 and 2000 biological opinions. For instance, EBS pollock catch in critical habitat increased from less than 20% of the annual TAC in 2000 to 50% in 2002, rising 255% in the 10–20 nm zone of critical habitat due to the displacement of fishery catches from 0–10 nm and representing 15% of the total catch in 2002. Total catch in critical habitat rose 49% from 1999 (329,095 tons) to 2002 (738,383 tons).[105]

Since 2002, NMFS has failed to officially estimate catch in critical habitat. However, unofficial statistics indicate that EBS pollock catches in critical habitat have returned to levels comparable to the 1990s (see Figure 24).

The failure to apportion the eastern Bering Sea pollock TAC into management subareas (except for a provision limiting the A-season catch in the SCA to 70% of the TAC before April 1) encourages spatial concentration of the

EBS pollock fishery. Despite taking slightly lower percentages of the EBS pollock catch from the SCA foraging habitat in recent years, the fishery remains concentrated in the southeastern Bering Sea between Unimak Pass and the Pribilof Islands. An average of 75% of the total annual catch has been taken in this region of the Bering Sea since 1999, up from an average of 66% from 1979–1998. Yet less than a third of the estimated pollock biomass in the Bering Sea is found in this region, based on summer groundfish resource surveys.[106]

FIGURE 28. BERING SEA SUMMER EIT (ACOUSTIC) SURVEY POLLOCK BIOMASS DISTRIBUTION, 1994–2004

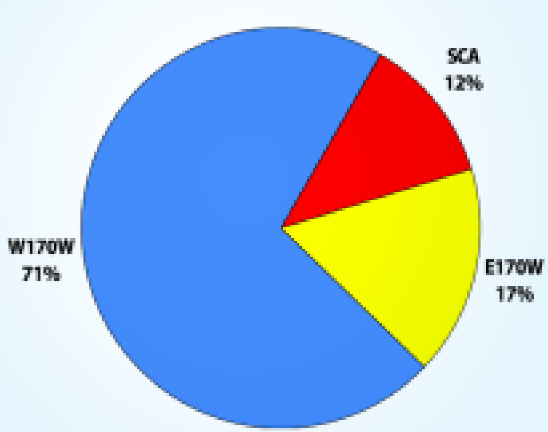
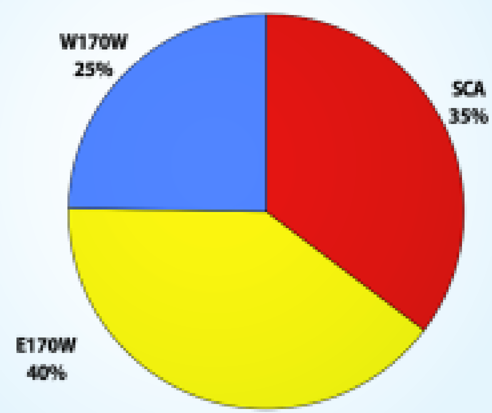


FIGURE 29. PERCENTAGE POLLOCK CATCH BY AREA IN SCA, E170˚W AND W170˚W, 1999–2003



SOURCE: The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2004).

Concentration of the TAC in the southeastern Bering Sea raises the fishery exploitation rate (catch/biomass) far above what is estimated relative to the theoretical "stock as a whole," 60-70% of which has consistently been located in areas west of 170° West (northwest of the Pribilof Islands) during the summer surveys. The consequences for competing pollock predators such as sea lions and fur seals may be profound, resulting in catch rates of 20-60% of standing biomass in the SCA during past B seasons,[107] and indications of a similar effect in the southeastern Bering Sea foraging habitat of fur seals from the Pribilof Islands.[108]

In the west-central Gulf of Alaska, the pollock TAC is subdivided into three broad management subareas based on estimates of pollock stock biomass distribution from resources surveys, as shown for 2004 in Table 29.

TABLE 29. ALLOCATION OF 2004 GULF OF ALASKA POLLOCK TAC (METRIC TONS) BY SEASON AND MANAGEMENT SUBAREA, BASED ON ESTIMATED STOCK BIOMASS DISTRIBUTION

Season	Shumagin 610	% stock	Chirikof 620	% stock	Kodiak 630	% stock	Total
A: 20 Jan	3,747	23.6%	9,027	56.9%	3,091	19.5%	15,865
B: 10 Mar	3,748	23.6%	10,704	67.5%	1,413	8.9%	15,865
C: 25 Aug	7,717	48.6%	3,380	21.3%	4,768	30.1%	15,865
D: 1 Oct	7,718	48.6%	3,379	21.3%	4,768	30.1%	15,865
All year	**22,930**	**36.0%**	**26,490**	**42.0%**	**14,040**	**22.0%**	**63,460**

SOURCE: Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska (2003).

However, efforts to apportion the Gulf of Alaska pollock TAC by subareas and across seasons are plagued by uncertainty, especially when deciding "how best to approximate seasonal migration amongst areas in the absence of seasonally explicit spatial information."[109] Pollock migrate from winter spawning grounds and summer foraging habitats, and their movements are poorly understood. Regional biomass estimates from the biennial summer bottom trawl surveys are highly variable, "indicating either large variability, large interannual changes in distribution, or, more likely, both."[110] Thus, even when survey biomass estimates are available for an entire region, there is high uncertainty as to the actual stock distribution in a given location.

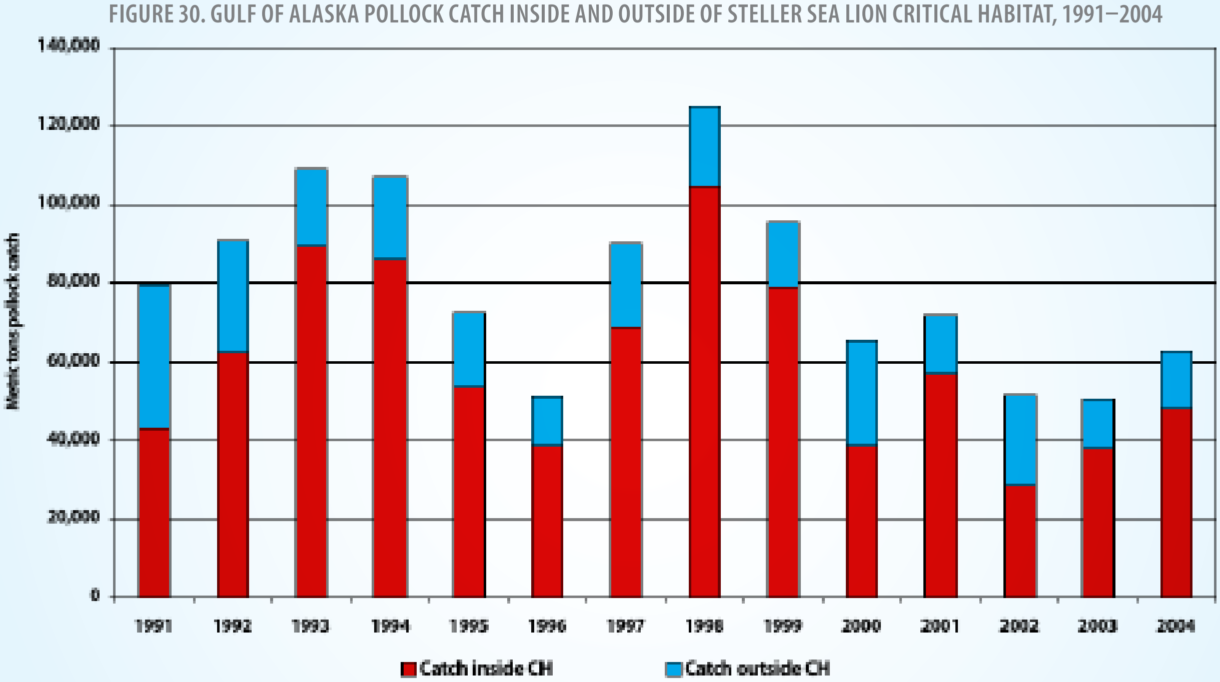
There is considerable risk that pollock and pollock predators alike are adversely affected by the existing spatial and temporal allocation scheme, particularly given the highly localized and concentrated distribution of the fishery within individual management subareas:

> *Although spatial apportionment is intended to reduce the potential impact of fishing on endangered Steller sea lions, it is important to recognize that apportioning the TAC based on an inaccurate or inappropriate estimate of biomass distribution could be detrimental, both to [the] pollock population itself, and [to] species that depend on pollock.*[111]

The limitations and inadequacies of the available survey distribution data for Gulf pollock highlight the problems and trade-offs associated with spatial-temporal management of TACs generally, as NMFS acknowledges.[112]

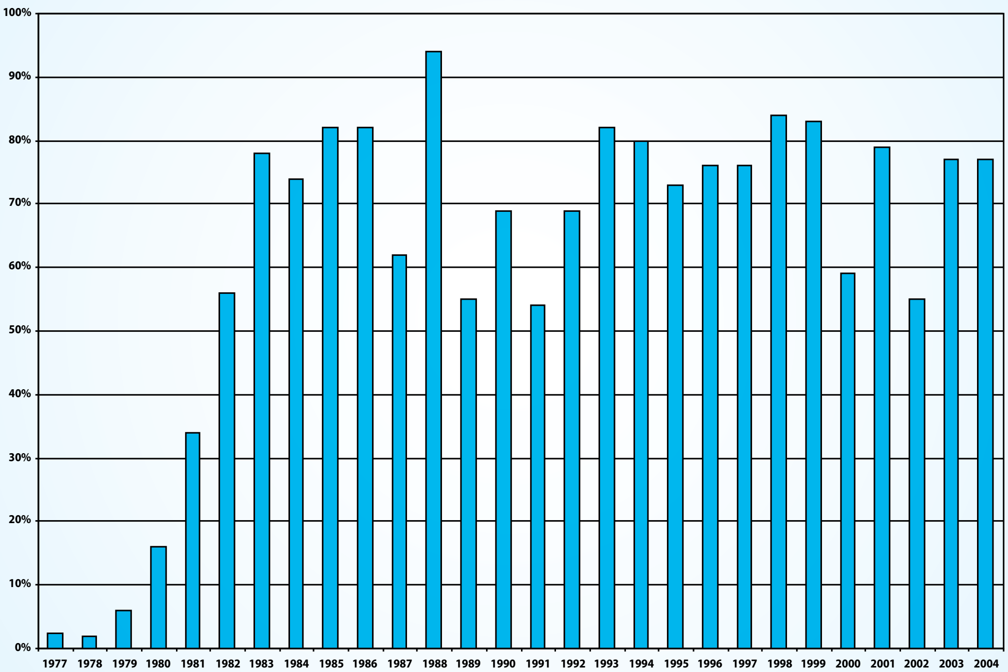
In 2002, Gulf of Alaska pollock catches in critical habitat decreased 34%.[113] According to the NMFS analysis, much of the decrease in fishing effort in critical habitat during 2002 was attributable to low pollock biomass inside the Shelikof Strait foraging area and movement of the fishery farther offshore in search of fishable concentrations.[114] Since there are no overall pollock catch limits in Gulf of Alaska critical habitat, NMFS cautioned in 2003 that "it is not clear if the same low catch amounts will continue in the near future in the 10–20 nm zone."[115] Indeed, while the total tonnage of Gulf of Alaska pollock catches has dropped in recent years due to low stock biomass, the overall percentage of the annual pollock catch taken from critical habitat is as high as ever today, averaging 70–75% in the periods before and after 2001 (see Figures 30, 31).

FIGURE 30. GULF OF ALASKA POLLOCK CATCH INSIDE AND OUTSIDE OF STELLER SEA LION CRITICAL HABITAT, 1991–2004



SOURCE: NMML, unpublished data; NMFS, *Supplement to the Endangered Species Act—Section 7 Consultation Biological Opinion and Incidental Take Statement of October 2001* (2003).

FIGURE 31. PERCENT OF ANNUAL GULF OF ALASKA POLLOCK CATCH IN STELLER SEA LION CRITICAL HABITAT, 1977–2004



SOURCE: NMML, unpublished data; NMFS, *Supplement to the Endangered Species Act—Section 7 Consultation Biological Opinion and Incidental Take Statement of October 2001* (2003).

In effect, NMFS is now saying that levels of fishery catches in critical habitat that caused jeopardy and adverse modification as reported in the 2000 FMP BiOp (which remains in effect) are no longer a concern as long as they are concentrated outside the 0–10 nm zone.

Northern fur seal © 2006 Todd Warshaw/Greenpeace USA.

NORTHERN FUR SEALS: ONGOING DECLINES PARALLEL THE RISE OF LARGE-SCALE TRAWL FISHERIES FOR POLLOCK

The Pribilof Islands fur seal rookeries are the reproductive center for approximately three-quarters of the population of northern fur seals in the North Pacific. These islands also support some of the largest seabird breeding and nesting colonies in the Pacific Ocean, and supported large numbers of Steller sea lions and harbor seals as recently as the 1960s.[116] The vast numbers of seals, sea lions, and seabirds historically reported at these islands testify to the enormous productivity of the surrounding marine environment, situated ideally near the oceanic convergence zones of the inner and outer domains of the eastern Bering Sea.[117]

BRIEF HISTORY OF FUR SEALS AT THE PRIBILOF ISLANDS

- 1780s: Pribilof Islands discovered by Russians; sea otters and walrus disappeared within 50 years
- 1786–1828: Average of approximately 100,000 fur seal skins/year shipped from the Pribilofs; females protected and harvest regulated beginning in 1830s
- 1870–1909: Americans regulated land harvest but pelagic sealing nearly exterminated the Pribilof fur seals
- 1911: International Fur Seal Treaty stopped pelagic fur seal hunt (and protected the remnant sea otter population)
- 1912–1955: Pribilof fur seals recovered to approximately 2.5 million animals in mid-1950s during period of negligible fishing in Bering Sea, despite continuing male harvest
- 1956–1968: "Controlled removal" of 300,000 females for population control

FIGURE 32. NORTHERN FUR SEAL RANGE IN THE NORTH PACIFIC AND MAIN BREEDING/PUPPING GROUNDS IN THE EASTERN BERING SEA – TOTAL NUMBERS HAVE DECLINED FROM 2.5 MILLION IN 1950s TO .5 MILLION TODAY (ESTIMATES)

SOURCE: NMFS, *Alaska Groundfish Fisheries Final PSEIS* on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans(2004).

The northern fur seal population reached peak levels for the 20th century in the 1950s following several decades of sustained population growth from the harvest-depleted levels of the early 20th century, which prompted complaints by Japan that fur seals were too numerous and interfering with its developing factory fisheries.[118] These concerns led to a restoration of female culling from 1956–1968, during which time approximately 300,000 females were removed from the population.[119] With the end of the culling program, fur seal numbers briefly rose before turning sharply downward beginning in the mid-1970s. This period of rapid fur seal decline coincides with the establishment of a large December–May trawl closure zone known as the Winter Halibut Savings Area off the eastern Aleutian Islands,[120] which displaced much of the massive Japanese pollock fishery of that era to the north-northwest into areas of the Bering Sea where foraging female fur seals are commonly found during May–November.

From the mid-1970s to early 1980s, the fur seal population on the Pribilof Islands declined by more than half, from 1950s levels of 1.8–2.1 million to fewer than 1 million, resulting in the designation of the population as depleted under the Marine Mammal Protection Act in 1988. Despite an apparent leveling off at this lower level in the 1980s, the smaller fur seal colonies on the southernmost island of St. George continued to decline. More mysterious is why fur seal numbers have not rebounded toward the historic levels of the 1950s as they did in the decades following the cessation of the at-sea commercial harvest under the international Treaty for the Preservation and Protection of Fur Seals and Sea Otters in 1911.[121,122]

Pup counts on both St. Paul and St. George Islands have declined slowly but steadily for many years and are now at the lowest levels since the low-water marks of 1918 and 1916, respectively, when commercial harvests of fur seals badly depleted the population.[123] Estimates of total fur seal pups born in 2004 were 122,825 on St. Paul Island and 16,876 on St. George Island. This compares with estimates of Pribilof fur seal pup production of over 500,000/year during the 1940s and 1950s.[124] During 1998–2004, pup production on St. Paul Island declined at 6.2% per year and declined at 4.5% per year on St. George Island. For the Pribilof Islands as a whole, excluding Sea Lion Rock,[125] pup production declined at 6% per year during this most recent period.[126] It appears that pup production has likely experienced a consistent decline of nearly 2% annually since 1990, continuing a pattern seen since the 1970s.[127]

DECLINING FUR SEAL NUMBERS POINT TO A FOOD-LIMITING CAUSE

In the absence of some other obvious cause for the failure of the fur seal population to rebound toward historic levels, such as entanglement in net debris or disease, the declining numbers in this otariid pinniped point to a food-limiting cause. As noted by NMFS, however, there is no compelling evidence that environmental carrying capacity has declined substantially since the late 1950s to an equilibrium level.[128] If the declining fur seal population at the Pribilof Islands is food-limited, something other than a massive decline in the carrying capacity of the eastern Bering Sea ecosystem is responsible.

Studies of Northern and Southern Hemisphere fur seal species show strong links between food availability and reproductive success.[129] As with the Steller sea lion, fur seal reproduction is energetically expensive for the mother. For example, Perez and Mooney found that the average daily feeding rate for lactating northern fur seals was 1.6 times higher (60% greater) than for nonlactating females.[130] Studies of fur seals generally indicate that food shortages in one season may affect the pregnancy status of females in subsequent seasons, blocking estrus, terminating pregnancy, and preventing lactation.[131] Low birth rates in both northern fur seals and Steller sea lions throughout this region indicate that females are not getting adequate food supplies to deliver and support newborn pups year after year.

Similarly, the National Research Council noted that growth and survival of fur seal and Steller sea lion pups "is likely to be affected by the foraging success of females during the lactation period."[132] The length of the nursing period may also vary as a function of the condition of the adult female.[133,134] If the mother suffers from food stress, she may abandon the pup before it has developed the foraging skills to survive on its own. Fur seal pups are weaned more abruptly than sea lion pups and these immature animals are vulnerable to shortages or changes in availability of prey because they have less-developed foraging skills and need to consume more food per unit of body mass than adults to support growth.[135] All of these findings underscore the importance of maintaining adequate food supplies in the North Pacific to support robust populations of these top predators.

Northern fur seals at rookery on St. Paul Island in Alaska © 2006 Todd Warshaw/Greenpeace USA.

POLLOCK HAS LONG BEEN A STAPLE OF FUR SEAL DIETS DURING THEIR STAY IN THE EASTERN BERING SEA

Northern fur seal diet studies provide the most extensive long-term food habits database available for any species in the North Pacific. Pollock's importance as a staple in the fur seal diet during their stay in the eastern Bering Sea is reported in every study since the 19th century, regardless of the climate regime, hence the scientific genus given to this hake-like member of the Gadid family by Jordan and Evermann, *Theragra*, meaning "beast food."[136] A recent technical review of the eastern Bering Sea pollock fishery for the Marine Stewardship Council concluded that pollock's importance in the Bering Sea food web is akin to the keystone role played by forage species such as krill, sandeel, and capelin in other marine ecosystems around the world.[137]

Research from the late 19th century indicates that pollock was a major prey item of fur seals in the Bering Sea, along with squid and smelt.[138] Jordan and Evermann reported that pollock was "excessively abundant" in the Bering Sea, and supplied a major part of the fur sea diet.[139] Studies since then have indicated pollock's importance to fur seals during their stay in the Bering Sea with remarkable consistency. Wilke and Kenyon concluded that fur seals depend heavily on pollock and other gadids.[140] Fiscus et al. reported similar overall results, with important spatial and temporal differences in prey consumption.[141] Kajimura showed distinct differences in prey consumption depending on the area and time of year sampled, and noted that walleye pollock was the leading prey when fur seal specimens were collected on the shelf or near the shelf edge in the eastern Bering Sea.[142] In studies from the early 1970s, during the peak years of the foreign pollock fishery, sampling within 100 miles of the Pribilof Islands indicated that pollock was the principal prey, contributing 67–74% of the total stomach content of individual animals collected by researchers, and the size of pollock eaten varied depending on depth and distance from the islands.[143]

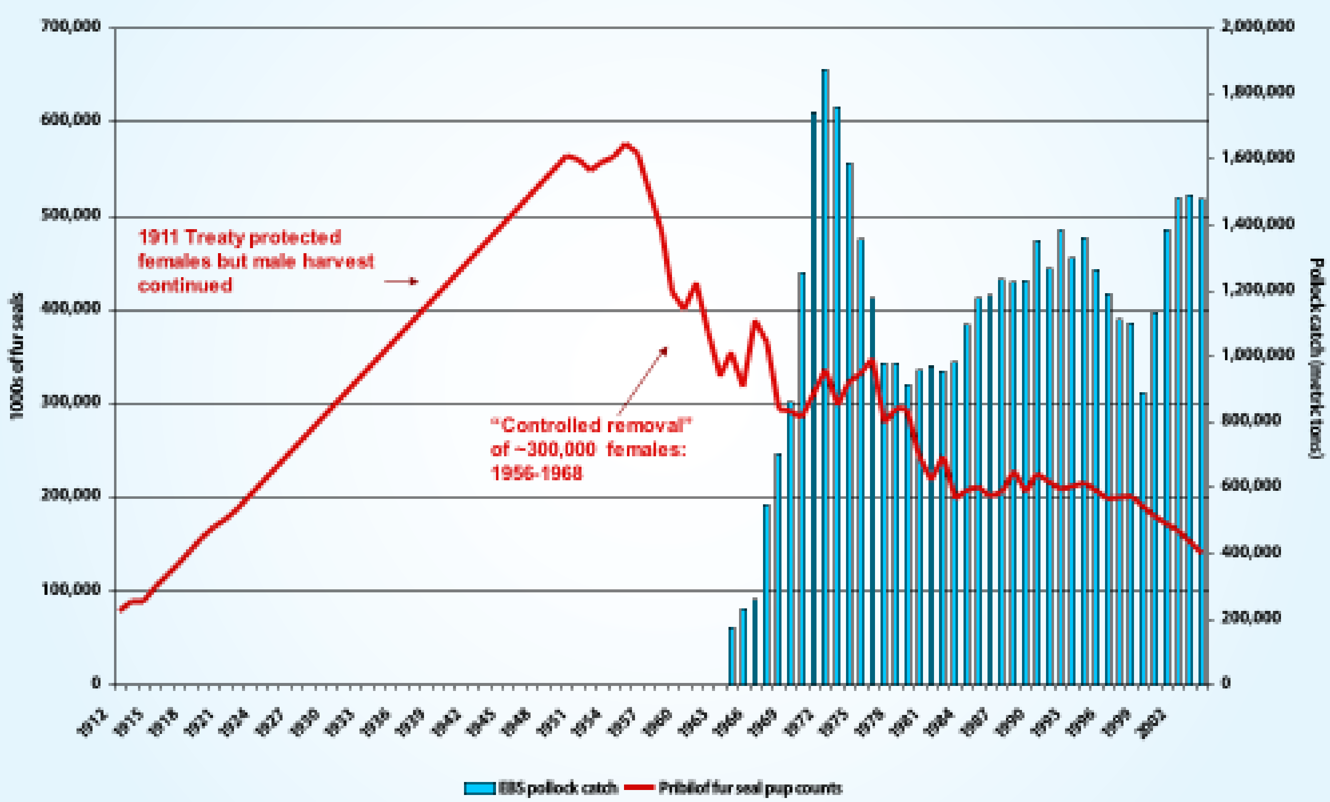
In 1994, Sinclair et al. speculated that other prey types, such as capelin, had "disappeared" from the diet, based on limited sampling of animals from the early 1980s.[144] The apparent increase in reliance on pollock in this early 1980s sample has been cited by some as evidence of the malignant effects of a climate-driven regime shift in 1997, presumably leading to a decrease in "preferred" forage fishes with higher fat content and energy density. It must be noted, however, that the sample size of animals from Sinclair's 1994 study was much smaller than that of the earlier studies of Fiscus, Kajimura, and others, and the data were heavily biased toward land-based sampling on the Pribilofs, and included very few animals from at-sea locations near Unimak Pass in the southeastern Bering Sea where Fiscus et al. had previously reported the high levels of fur seal capelin consumption in late spring. A thorough review conducted by scientists at the Alaska Fisheries Science Center found "little support for the hypothesis that increases in the availability of gadids [e.g. pollock] following the regime shift are primarily responsible for the decline of the western population of Steller sea lions."[145]

Most recently, Robson reported that pollock was the dominant prey species in the diet of lactating female fur seals studied in 1995 and 1996 on the Pribilof Islands, occurring in 61% of scats or enemas sampled from St. George Island in 1995 and 100% of the scats sampled from northeast St. Paul Island in 1995.[146]

NORTHERN FUR SEAL FORAGING HABITAT AND PREY AVAILABILITY IS VULNERABLE TO LARGE-SCALE POLLOCK TRAWLING, ESPECIALLY IN THE SOUTHEASTERN BERING SEA

A historical perspective on Pribilof fur seal trends over the course of the 20th century suggests that the enormous productivity of the eastern Bering Sea changed in the second half of the century so that the ecosystem can support only about one-third of the fur seals today compared to the mid-1950s. As noted above, however, there is no evidence that environmental carrying capacity has declined substantially since the late 1950s to a new equilibrium level.[147] Why haven't fur seal numbers rebounded robustly as they did following the cessation of the at-sea commercial harvest under the international Treaty for the Preservation and Protection of Fur Seals and Sea Otters in 1911? If the declining fur seal population at the Pribilof Islands is food-limited, something other than a massive decline in the carrying capacity of the eastern Bering Sea ecosystem is responsible. What is different about the ecosystem today? It is difficult to avoid the conclusion that the main difference in the ecosystem is the presence of large-scale fisheries targeting prime fur seal prey in the second half of the 20th century (see Figure 33).

FIGURE 33. PRIBILOF FUR SEALS DECLINE DESPITE END OF CONTROLLED REMOVALS



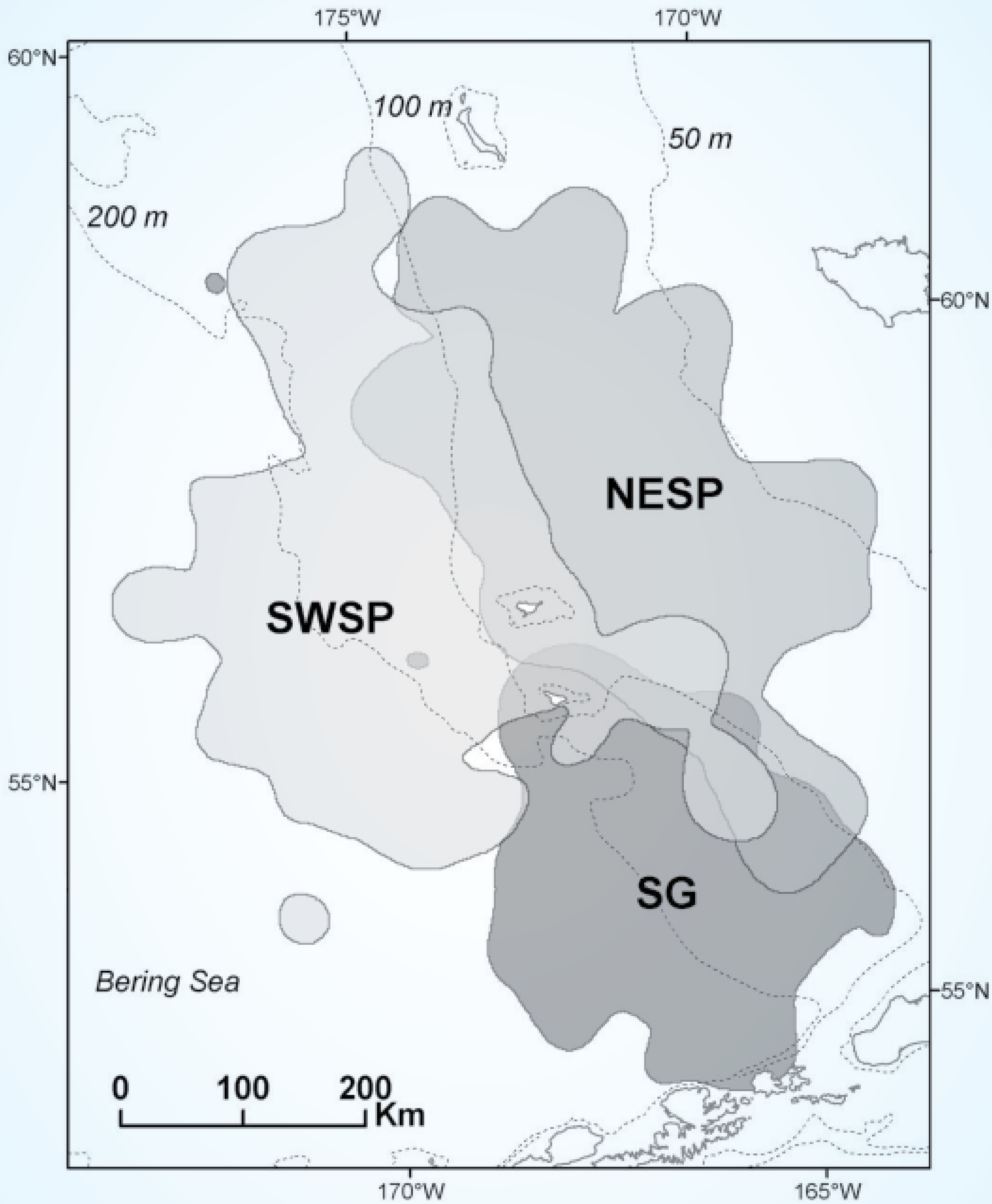
SOURCE: NMML, unpublished data; James Ianelli et al., "Assessment of Alaska Pollock Stock in the Eastern Bering Sea," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions* (2005).

In recent years, fishing effort for pollock has increased in nearshore areas around the Pribilof Islands where northern fur seals are known to forage.[148] The greatest potential for temporal overlap between northern fur seals and the pollock fishery in the eastern Bering Sea is July through November. Under the provisions of the American Fisheries Act, the pace of pollock fishing has slowed somewhat and the length of the B-season fishery has been extended from late June through October. This disperses the harvest over a longer time period than in previous seasons, but this change also extends the fishery into the summer months when fur seals are concentrated on the Pribilof Island rookeries and thus increases the likelihood of localized effects in foraging areas near the Pribilofs.[149]

Foraging female fur seals with dependent pups range over large areas of the eastern Bering Sea continental shelf and slope in search of food supplies. The average foraging range of fur seals is within 81–135 nm (150–250 km) of the rookeries, and juvenile males range even farther from shore than lactating females.[150,151] Based on these studies, meta-home ranges for female fur seals with pups have been mapped, indicating that much of the eastern Bering Sea middle domain, outer domain, and shelf break is utilized as foraging habitat by these animals, and reflecting the elevated productivity in these regions.[152,153] The telemetry data also show that foraging fur seal females from St. George Island preferentially utilize areas in the southeastern Bering Sea, and NMFS has concluded that the risk of fishery competition is higher in this region:

> *There has been concern with regard to displaced/increased fishing effort that is encroaching into nearshore areas of the Pribilofs resulting in increased overlap with fur seal foraging areas. The proportion of the total June–October pollock catch in fur seal foraging habitat increased from an average of 40 percent in 1995–1998 to 69 percent in 1999–2000 …There is particular concern that this increased fishing pressure could have impacted lactating females from St. George Island where catch rates were consistently higher than in areas used by females from St. Paul.*[154]

FIGURE 34. PRIBILOF ISLANDS FUR SEAL FORAGING RANGES FROM ST. GEORGE ISLAND (SG), SOUTHWEST ST. PAUL ISLAND (SWSP), AND NORTHEAST ST. PAUL ISLAND (NESP), AS ESTIMATED FROM TRACKING DATA



SOURCE: Bruce W. Robson et al., "Separation of Foraging Habitat Among Breeding Sites of a Colonial Marine Predator, the Northern Fur Seal (*Callorhinus ursinus*)," *Canadian Journal of Zoology* 82, no. 1 (2004): 20-29.

HABITAT IMPACTS OF POLLOCK TRAWLING

The continental shelf and slope off southwest Alaska comprise one of the most extensive fishing grounds in the world. The more than 900,000 mi^2 area of the EEZ off Alaska is larger than the land area of all the U.S. states east of the Mississippi River. NMFS calculates that 41.5% of the combined area of the Bering Sea/Aleutian Islands and 30% of the Gulf of Alaska EEZ occurs at depths less than 1,000 meters (i.e., on the continental shelf and slope), defined as the "fishable area" where groundfish fishing occurs.[155]

Most of the groundfish catch is taken with trawl gear in the Alaska region as a whole, although fixed gears account for a larger proportion of the Gulf of Alaska catch (see Figures 35, 36).

In the eastern Bering Sea, pollock trawling is concentrated on the productive upwelling zone along the western edge

FIGURE 35. ALL ALASKA GROUNDFISH CATCH BY GEAR TYPE, 2004

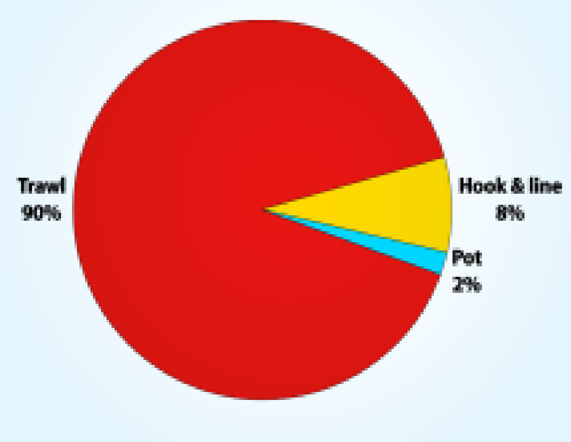
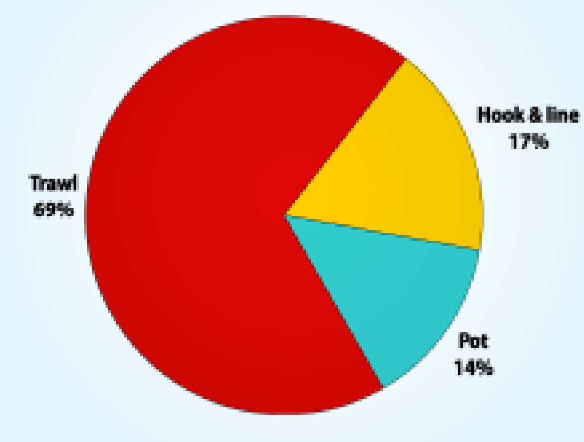


FIGURE 36. GULF OF ALASKA GROUNDFISH CATCH BY GEAR TYPE, 2004



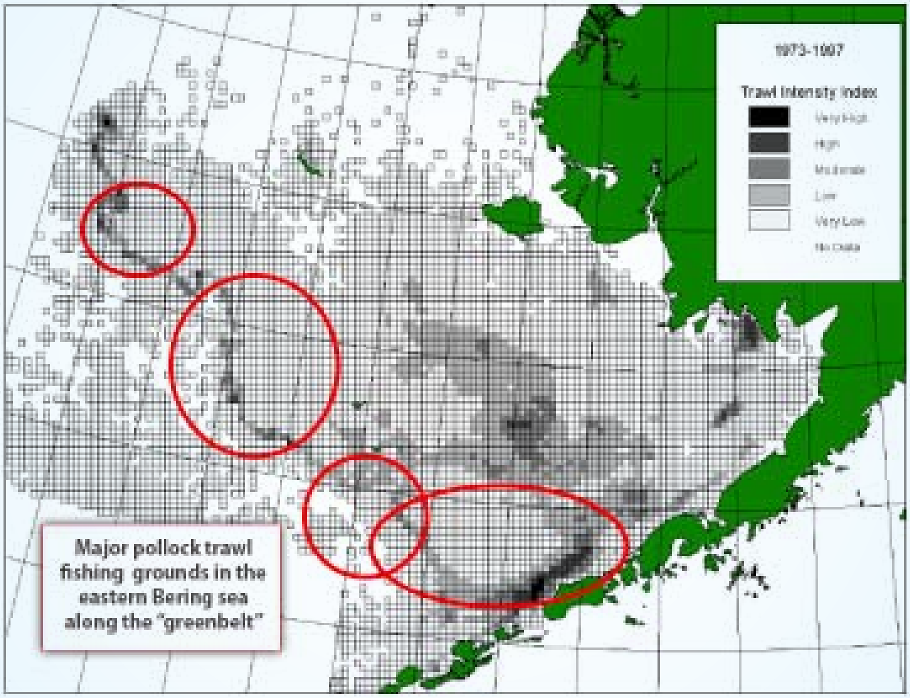
SOURCE: The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (2005).

of the shelf and slope between the 100-200 depth contours (the so-called "greenbelt"), and along the north side of the eastern Aleutian Islands and Alaska Peninsula near Unimak Island.[156] In the Gulf of Alaska, the shelf is narrower and pollock trawling is concentrated in highly localized portions of the Shelikof Strait submarine canyon, and to a lesser extent along the shelf-edge.[157] In the Bering Sea, pelagic trawl gear has been required since bottom trawl gear was prohibited in 1999. Most of the Gulf of Alaska catch (approximately 90%) is also taken with pelagic trawls.

The 1981 Final Bering Sea/Aleutian Islands EIS on the BS/AI Fishery Management Plan concluded that the use of pelagic (off-bottom) trawl gear "would mitigate the adverse impacts of commercial groundfish operations on the natural environment by substantially reducing the incidental harvest of halibut and crab, and by minimizing the disturbance of these and other forms of benthic marine life."[158] In June 1998, the NPFMC voted to prohibit all bottom trawl gear in the Bering Sea pollock fishery as a way of reducing bycatch and benthic habitat impacts. However, adult pollock are bottom-tending during the daylight hours when trawling occurs, and pelagic nets do come into contact with the sea floor, whether inadvertently or intentionally. Pelagic trawl gear reduces impacts to the seabed habitat and reduces bycatch of bottom-dwelling species but does not eliminate those impacts.

The use of pelagic trawl gear is cited as evidence of the pollock fishery's benign impact on marine habitat. However, even if pollock trawl nets had no contact with the sea floor whatsoever, the impact to the benthos is but one important

FIGURE 37. POLLOCK TRAWL-FISHING GROUNDS ALONG THE EASTERN BERING SEA "GREENBELT"



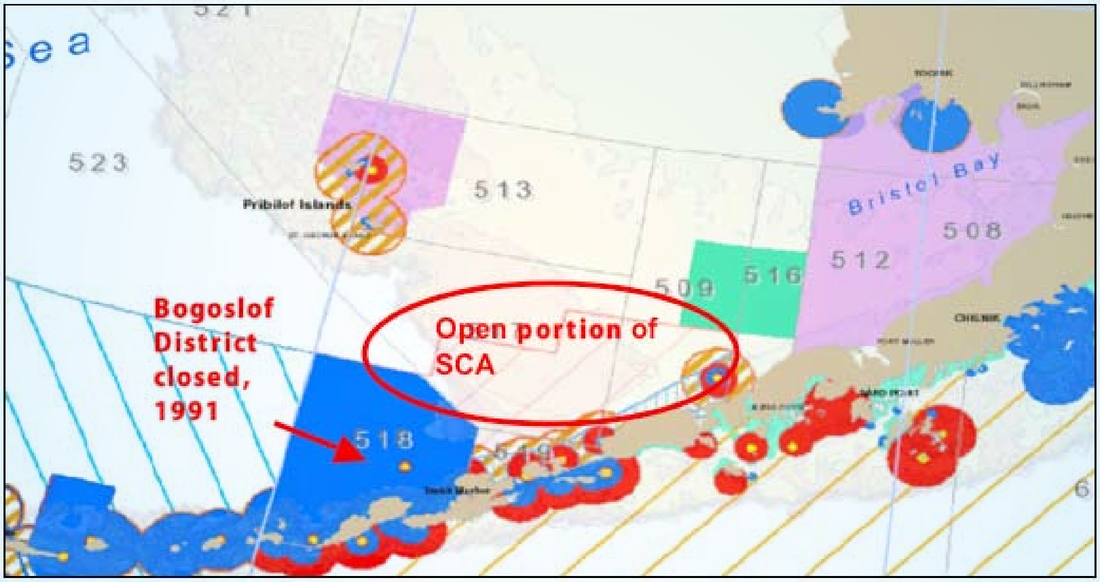
SOURCE: NMFS, *Alaska Groundfish Fisheries Final PSEIS* on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery

aspect of habitat to consider. In addition, pelagic trawl gear efficiently catches spawning pollock that cluster together. Specifically, 40% of the Bering Sea pollock TAC and 50% of the Gulf of Alaska TAC are allocated to the January-March spawning period, when pollock are densely aggregated in small areas of their year-round habitat range. This accounts for the intense spatial concentration of the pollock catch in areas of the southeastern Bering Sea near the eastern Aleutian Islands and portions of the Shelikof Strait near Kodiak Island. The targeting of pollock spawning grounds became standard practice in the 1980s, and pollock stocks in the Gulf of Alaska (Shelikof Strait), Aleutian Basin (Bogoslof Island region) and Aleutian Islands plummeted. The removal of nutritionally valuable fish is a modification of habitat for species dependent on that fish for food.

SPAWNING GROUNDS OFF THE EASTERN ALEUTIAN ISLANDS ARE GROUND ZERO FOR THE JANUARY-MARCH EASTERN BERING SEA POLLOCK ROE FISHERY

In the late 1980s and early 1990s, the Americanized pollock fishery became increasingly concentrated in January-March on pollock spawning grounds in areas now designated as Steller sea lion critical habitat. Following the closure of the international waters of the central Bering Sea Donut Hole and U.S. waters of the Bogoslof District (Area 518) after 1991, due to overfishing, a massive winter roe fishery developed on the large pollock spawning grounds off the eastern Aleutian Islands. This was conveniently located near the fish processing plants at Dutch Harbor and Akutan—all within the boundaries of the large aquatic foraging zone off the eastern Aleutian Islands, known today as the Sea lion Conservation Area (SCA). By the mid-1990s as much as 70% of the entire annual Bering Sea pollock catch was taken inside the SCA.

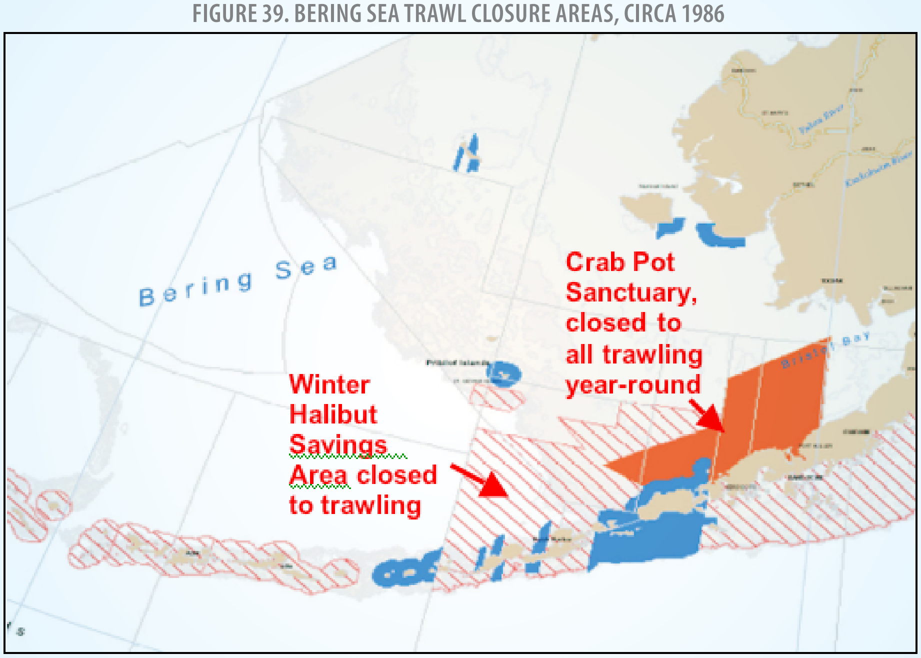
FIGURE 38. OPEN PORTION OF SEA LION CONSERVATION AREA



SOURCE: NMFS, *Alaska Groundfish Fisheries Final PSEIS* on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery

This spawning assemblage was hardly fished prior to 1986,[159] for two reasons: the existence of what was then called the Winter Halibut Savings Area, which was closed to foreign trawlers from January-May, and the adjacent Bristol Bay Crab Pot Sanctuary, which was closed to all trawling year-round (see Figure 39).

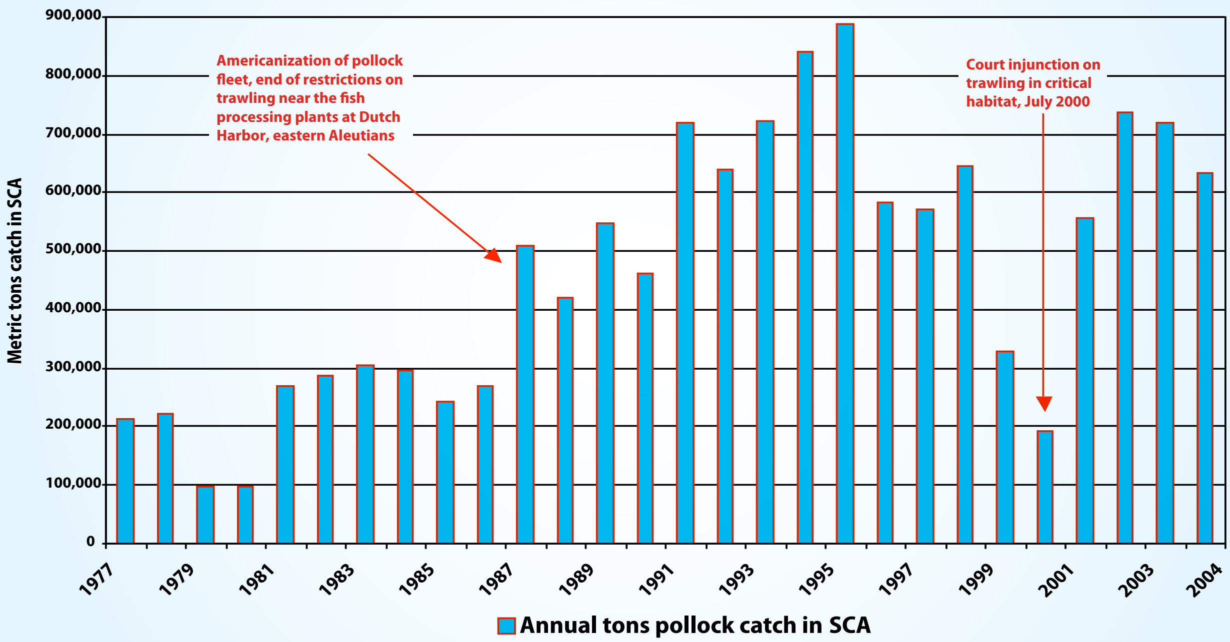
FIGURE 39. BERING SEA TRAWL CLOSURE AREAS, CIRCA 1986



SOURCE: NMFS, *Alaska Groundfish Fisheries Final PSEIS* on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery

With the opening of these foreign trawl closure areas to domestic trawlers in 1987, eastern Bering Sea pollock catches in the SCA during the winter spawning season skyrocketed from the negligible levels of the early 1980s to over half a million tons by the mid-1990s.[160] Despite closure of the Bogoslof portion of the SCA in 1991 and closure of some nearshore areas of the SCA as part of sea lion mitigation measures in 2002-2004, the pollock fishery continues to concentrate on these spawning grounds at levels comparable to the 1990s (see Figure 40).

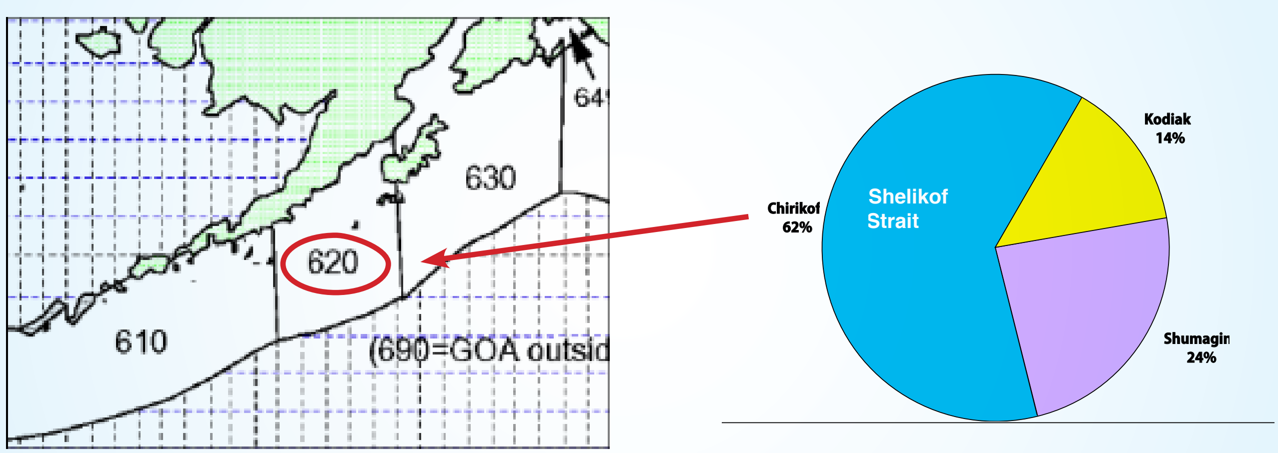
FIGURE 40. POLLOCK CATCH INSIDE THE SOUTHEASTERN BERING SEA SEA LION CONSERVATION AREA, 1977-2004



SOURCES: NMML (Unpublished data); NMFS, *Supplement to the Endangered Species Act—Section 7 Consultation Biological Opinion and Incidental Take Statement of October 2001* (2003).

The seasonal and spatial apportionment scheme in today's Gulf pollock fishery concentrates half of the annual TAC on the spawning grounds. Over 60% of the A-B season (January-March) TAC is apportioned to the Shelikof Strait spawning grounds because nearly two-thirds of the pollock "stock" is believed to be located in the Shelikof Strait area in winter and early spring (see Figure 41).

FIGURE 41. GULF OF ALASKA POLLOCK CATCH ALLOCATIONS



SOURCE:Dorn et al., "Assessment of Walleye Pollock in the Gulf of Alaska," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska* (2005).

Exploratory winter acoustic surveys of areas outside the Shelikof Strait have been sporadically conducted. Limited survey data indicates that smaller spawning aggregations are located in the Shumagin Islands and east of Kodiak Island, although the relationship of these spawning populations to the Gulf of Alaska "stock" as a whole is unclear. The continuing low abundance of the once-large Shelikof Strait spawning aggregation apparently has not reduced its relative importance as a source of stock production. The "discovery" of spawning aggregations outside Shelikof Strait has been hailed by fishing interests as a way of downplaying the depleted state of the Shelikof spawning aggregation, but there is much uncertainty regarding the persistence, abundance, and relationships among these separate spawning aggregations.[161]

WEAK 1996 MAGNUSON-STEVENS ACT ESSENTIAL FISH HABITAT (EFH) PROVISIONS HAVE NOT PROTECTED ESSENTIAL POLLOCK HABITAT

- **MSA Sec. 303(a)(7) requires any FMP to "describe and identify essential fish habitat for the fishery" and "minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat." 16 U.S.Code § 1853**
- **Sec. 305(b) requires "description and identification of essential fish habitat in fishery management plans (including adverse impacts on such habitat) and in the consideration of actions to ensure the conservation and enhancement of such habitat." 16 U.S.Code § 1855.**
- **The MSA's "qualifying EFH language," to the extent practicable, is the statutory escape clause that permits councils to avoid adopting habitat protection measures for FMP-managed species that would constrain fishing.**
- **Scientific burden of "proof" of habitat damage is very high: must show harm before taking action to protect habitat, which is the opposite of a precautionary approach.**

Perhaps the most significant amendment to the reauthorized Magnuson-Stevens Act of 1996 is the requirement for describing, identifying, and protecting the essential fish habitats of managed species for each major life history stage. The MSA requires fishery management plans to consider and minimize adverse effects on EFH caused by fishing "*to the extent practicable*."[162] This qualifying language is the statutory escape clause that has permitted the NPFMC and other councils to avoid adopting habitat protection measures for FMP-managed species that would constrain fishing.

Under the MSA's EFH provisions, no EFH of managed groundfish species was protected when BSAI and GOA FMP Amendments 55/55 implemented the EFH regulations in 1999. Currently there are no explicit EFH protection measures for actively fished pollock stocks at any life history stage,[163] although closed nearshore areas of sea lion critical habitat may provide some refuge and the continued closure of the Bogoslof District under the terms of the Convention on the Conservation of Pollock in the central Bering Sea (Donut Hole Treaty, 1992) provides protection for a depleted spawning aggregation that was once a major source of Aleutian Basin pollock.

Unfortunately, the Magnuson-Stevens Act leaves EFH implementation to the regional fishery management councils, who generally do not vote for protective measures that conflict with their interests in the fisheries. The NPFMC's most recent 2005 EFH initiative for the Aleutian Islands portends council-controlled EFH implementation under the Magnuson-Stevens Act:

- Council-appointed EFH committee representing the major groundfish industry stakeholders is tasked with developing EFH alternatives for analysis and for selecting a preferred alternative EFH action plan (2002).

- Limited environmental representation is included on the committee, easily out-voted by industry representatives.
- Only a small area of the Aleutian shelf is to be closed to bottom trawling to protect “coral gardens,” and after two years of debate (2005).
- No groundfish habitat protected in areas targeted by bottom trawlers on-shelf in the Aleutians (Atka mackerel, cod).
- No marine reserves designated or proposed on major fishing grounds.
- Closure of 279,000 nm^2 of the Aleutian EEZ (off-shelf) to bottom trawling helps control expansion of groundfish fisheries but does not significantly impact existing trawl patterns.

The regional fishery management councils have not approached ocean habitat conservation comprehensively. Vested interests on the councils stymie efforts to address fishing impacts on established fishing grounds, even though the law seems to require them to do so. But the EFH regulations are easily overcome in the council process and the councils are given wide latitude to determine whether measures are “consistent with” the habitat protection provisions of the Magnuson-Stevens Act.

POLLOCK SPAWNING HABITAT PROTECTION NEEDED IN THE EASTERN BERING SEA AND GULF OF ALASKA

Only the large eastern Bering Sea pollock spawning aggregation off the eastern Aleutian Islands has withstood the annual assault of the roe fishery without collapsing. However, the practice of targeting pollock on spawning grounds when the fish are most vulnerable to trawl gear is a significant habitat impact. The pollock fisheries of the Bering Sea and Gulf of Alaska have major impacts on pollock reproductive habitats that have not been addressed by the Magnuson-Stevens Act’s EFH mandate:

- Despite the inclusion of amendments in 1996 mandating the conservation of essential fish habitat under the federal fisheries law, no pollock habitat is explicitly protected in the areas open to pollock fishing today.
- Existing trawl closure areas do not protect pollock spawning grounds in the fished areas of the Bering Sea and Gulf of Alaska and do not achieve the intent of protected areas that serve as “spatially defined area[s] in which all populations are free of exploitation.”[164]

The decline of several regional pollock stocks and large uncertainties in stock structure among pollock populations indicate the need for management protection of spawning grounds. In theory the MSA’s EFH provisions would not only permit but also require the adoption of marine reserves to protect vulnerable pollock reproductive habitats that are targeted by the fishery. As noted in recent Gulf of Alaska pollock stock assessments, protection of these pollock populations would be most important during spawning season, when they are most vulnerable to pelagic trawl gear:

- Species such as pollock range widely over the EEZ during portions of the year, but they return to natal spawning grounds within limited portions of their range during a short season.
- These spawning grounds are well known, they serve a vital ecological function in the life history of managed species, and they are vulnerable to large fisheries that target managed species in these habitats.
- Heavily exploited spawning grounds for pollock in Shelikof Strait, the Aleutian Islands, and Aleutian Basin have suffered major stock declines.

- Closures of the Bogoslof District (1992) and the Aleutian Islands (1998) to directed pollock fishing came after the damage was already done.
- Spawning grounds and other sensitive habitats are logical habitat types to designate as Essential Fish Habitat or Habitat Areas of Particular Concern and to protect with marine reserves.

EXISTING GEAR CLOSURE AREAS ARE NOT ADEQUATE TO PROTECT ESSENTIAL FISH HABITAT OF MANAGED SPECIES, PARTICULARLY POLLOCK HABITAT

Existing closure areas restrict trawl gear but allow fishing by other gear types — the exception being Steller sea lion protection measures (adopted in 2002) that also restrict hook-and-line and pot gear targeting cod in some areas. More than half of the areas designated prior to 2005 are bycatch-triggered only; two are brief seasonal closures.

- Status quo habitat protection measures consist mainly of bottom trawl closures in relatively shallow nearshore waters of crab habitat, and many of these protected zones are not closed year round to trawling.
- There is currently no habitat protection in the deeper waters of the outer continental shelf and slope of the west-central Gulf of Alaska and Bering Sea/Aleutian Islands.[165]
- There is a near absence of year-round closures to all fishing.[166]
- Most protected areas off Alaska allow fishing by gear other than trawl gear and therefore do not meet all criteria for marine protected areas.[167]

Groundfish trawl closure areas in the Bering Sea/Aleutian Islands and Gulf of Alaska regions are shown in Table 30 below. Prior to 2005, a total of 94,602 nm^2 (324,863 km^2) were closed all year to trawling or bottom trawling gear, roughly 30% of the continental shelf area less than 200 meters depth in the action area.[168] However, 52,600 nm^2 (55%) of that area is in southeast Alaska, far away from the main trawl fishing grounds of western Alaska.

TABLE 30. YEAR-ROUND TRAWL EXCLUSION ZONES, 1992-2002

Measure	Closure type	Area nm^2	FMP amendment	Year of adoption
Sea Lion rookery no-trawl zones	Trawl exclusion	22,000	BSAI Amend. 20/ GOA Amend. 25	1992
Kodiak red king crab zones	Bottom trawl exclusion	1,000	GOA Amend. 26	1993
Pribilof Is. habitat conser. area	Trawl exclusion	7,000	BSAI Amend. 21a	1995
Nearshore Bristol Bay closure	Trawl exclusion	19,000	BSAI Amend. 37	1996
Red King Crab Savings Area	Bottom trawl exclusion	4,000	BSAI Amend. 37	1996
Southeast Alaska no-trawl zone	Trawl exclusion	52,600	GOA Amend. 41	1998
Sitka Pinnacles Marine Reserve	Fishing exclusion	2.5	GOA Amend. 59	2000
Cook Inlet non-pelagic trawl ban	Bottom trawl exclusion	7,000	GOA Amend. 60	2002

SOURCE: he Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska, comps., Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions (2004)..

These trawl closure areas provide some habitat protection from trawling for crab stocks, marine mammals, and benthic habitat in nearshore areas, but they *do not* accomplish the aim of marine protected areas to provide refuges from fishing and the effects of fishing on habitat: "Most protected areas off Alaska allow fishing by gear other than trawl gear and may therefore not meet all criteria for 'marine protected areas.'"[169] Only the 3 nm no-entry zones around selected sea lion rookeries accomplish the intent of marine protected areas to serve as "spatially defined area[s] in which all populations are free of exploitation."[170]

Bycatch-triggered or seasonal trawl closure areas in the Bering Sea totaling 218,000 nm^2 (not including the walrus summer trawl exclusion zones in Bristol Bay and Steller sea lion seasonal trawl closures of critical habitat) *potentially* come under protection at some time of year. But these closure areas are either short lived or triggered only when prohibited species bycatch limits are reached (see Table 31).

TABLE 31. BERING SEA SEASONAL OR BYCATCH-TRIGGERED AREA CLOSURES*				
Measure	Closure type	Area nm^2	FMP amendment	Year of adoption
Tanner crab bycatch zones	Bycatch trigger	80,000	BSAI Amend. 12a	1989
Area 516 seasonal closure	King crab molting season	4,000	BSAI Amend. 21a	1989
Herring Savings Areas (3)	Bycatch trigger	30,000	BSAI Amend. 16a	1991
Chinook Salmon Savings Area	Bycatch trigger	9,000	BSAI Amend. 21b/ Amend. 58	1995, 2000
Chum Salmon Savings Area	August only	5,000	BSAI Amend. 37	1995
Opilio Tanner crab bycatch zone	Bycatch trigger	90,000	BSAI Amend. 40	1997
Maximum potential area		**218,000**		

*Does not include seasonal walrus and sea lion habitat area closures

SOURCE: The Plan Teams for the Groundfish Fisheries of the Bering Sea and Aleutian Islands, comps., Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions (2004).

While these closure areas play an important role in management of the Bering Sea, there is a near total absence of such habitat and bycatch-related closure areas in the Aleutian Islands and Gulf of Alaska. The absence of protected areas in pelagic shelf-edge habitat of the eastern Bering Sea and intensively exploited spawning grounds in both the Bering Sea and Gulf of Alaska are serious issues. To address the shortcomings in essential fish habitat protection for pollock and other groundfish species, a network of gear closure areas and marine reserves (understood as refuges from all fishing) is needed for the Bering Sea, Aleutian Islands, and Gulf of Alaska.

NOTES

OVERFISHING IN AN ECOSYSTEM CONTEXT

[1] Burr Heneman, "Federal Fishery Laws: New Model Needed to Sustain Fisheries and Ecosystems," in *Managing Marine Fisheries in the United States: Proceedings of the Workshop on Marine Fishery Management* (Arlington, VA: Pew Oceans Commission, 2002), 1-5.

[2] NMFS, *Alaska Groundfish Fisheries Final Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2004), ES-65 [hereafter cited as *Final PSEIS*].

[3] *U.S. Code* 16 § 1851.

[4] *U.S. Code* 16 § 1802.

[5] NMFS, *Final PSEIS*, ES-66.

[6] NMFS, *Endangered Species Act Section 7 Consultation—Biological Opinion and Incidental Take Statement* (2000), 208, 223-224 [hereafter cited as *FMP BiOp*].

[7] NPFMC, *Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area* (1999), 175: "In [an] ecosystem sense, there is no 'surplus' production in the sea for man to take."

[8] NMFS, *Final PSEIS,* (2004), App. F, p. F-1-20. See also: Witherell et al., 2000.

[9] The "$F_{40\%}$ harvest policy" is shorthand for the approach of allowing fishing to remove approximately 60% of the fish biomass from the marine environment.

[10] NMFS, *Final PSEIS*; NMFS, *FMP BiOp*.

[11] NMFS, *Alaska Groundfish Fisheries Draft Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2001), 5 [hereafter cited as *2001 Draft PSEIS*].

[12] Lowell W. Fritz, Richard C. Ferrero, and Ronald J. Berg, "The Threatened Status of Steller Sea Lions, *Eumetopias jubatus*, Under the Endangered Species Act: Effects on Alaska Groundfish Fisheries Management," *Marine Fisheries Review* 57, no. 2 (1995): 14-27.

[13] Robert C. Francis, Kerim Aydin, and Richard L. Merrick, et al., "Modeling and Management of the Bering Sea Ecosystem," in *Dynamics of the Bering Sea*," ed. Thomas R. Loughlin and Kiyotaka Ohtani, University of Alaska Sea Grant Report AK-SG-99-03 (Fairbanks, Alaska: University of Alaska, 1999), 425-426

[14] Committee on the Bering Sea Ecosystem, Polar Research Board, and Commission on Geosciences, Environment and Resources, et al., *The Bering Sea Ecosystem* (Washington, DC: National Academy Press, 1996), 24.

[15] NMFS, *FMP BiOp,* 225, 259. See also: NMFS, *Final PSEIS*, 1-17.

[16] NMFS, *FMP BiOp.*

[17] The Plan Teams for the Groundfish Fisheries of the Bering Sea/Aleutian Islands and Gulf of Alaska, comps. [hereafter referred to as "BS/AI and GOA Plan Teams", *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (Anchorage, Alaska: NPFMC, 2003); The Plan Teams for the Groundfish Fisheries of the Bering Sea/Aleutian Islands and Gulf of Alaska, comps., *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/ Aleutian Islands and Gulf of Alaska Regions* (Anchorage, Alaska: NPFMC, 2004).

[18] NMFS, *Alaska Groundfish Fisheries Draft Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2003), I, 3.8-21 [hereafter cited as *2003 Draft PSEIS*].

[19] Ibid., I, 3.8-5; IV, 5-31.

[20] Ibid., VIII, F-2-30.

[21] Committee on the Bering Sea Ecosystem et al., *The Bering Sea Ecosystem*. See also: *NMFS 2003 Draft PSEIS*, IV, 5-15; VIII, F-1-19.

[22] NMFS, *Final PSEIS*, 4.1-17.

[23] Richard C. Ferrero and Lowell W. Fritz, *Steller Sea Lion Research and Coordination: A Brief History and Summary of Recent Progress*, NOAA Technical Memorandum NMFS-AFSC-129 (Washington, DC: U.S. Department of Commerce, NOAA, 2002).

[24] Paul K. Dayton, Enric Sala, and Mia J. Tegner, et al., "Marine Reserves: Parks, Baselines, and Fishery Enhancement," *Bulletin of Marine*

Science, 66 (2000): 617-634.

[25] NMFS 1998, 63 FR 24220.

[26] NMFS, *FMP BiOp*, 208, 223-224.

[27] Pamela M. Mace, "Relationships Between Common Biological Reference Points Used as Thresholds and Targets of Fisheries Management Strategies," *Canadian Journal of Fisheries and Aquatic Sciences* 51 (1994).

[28] Daniel Goodman, Marc Mangel, and Graeme Parks, et al., *Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Fishery Management Plans—Draft report.* (Anchorage, Alaska: NPFMC, 2002), 7.

[29] Ibid., 85.

[30] NMFS, *FMP BiOp*, 225.

[31] Ibid., 259.

[32] Ibid., 289.

[33] See Fishery Management Plan AR 172, p. 41, RE: Chap. 6, handwritten questions: *At least two main questions to be resolved: 1) How do we know how much we can reduce prey availability without significant adverse effects (i.e., should we fish at* $F_{40\%}$, $F_{60\%}$, $F_{80\%}$, $F_{90\%}$*)?; and 2) How can we determine the safe level of removal from critical habitat?*

[34] J. Baird Callicott, *Beyond the Land Ethic: More Essays in Environmental Philosophy* (Albany, NY: State University of New York Press, 1999), 369.

[35] Steven A. Murawski, "Definitions of Overfishing from an Ecosystem Perspective," *ICES Journal of Marine Science* 57 (2001): 649-658.

[36] NMFS 1997, 62 FR 66551.

[37] Karl-Hermann Kock, ed,. *Understanding CCAMLR's Approach to Management* (2000), 7, http://www.ccamlr.org.

[38] Ibid., 8.

[39] R.B. Thomson, D.S. Butterworth, and I.L. Boyd, et al., "Modeling the Consequences of Antarctic Krill Harvesting on Antarctic Fur Seals," *Ecological Applications* 10 (2000): 1806-1819.

[40] Ibid.

[41] Kock, *Understanding CCAMLR's Approach*, 33.

[42] Ibid.

[43] Concerning ecological factors, the National Standard Guidelines give the scientific advisors and managers wide latitude to reduce the allowable fishing rates from the theoretical maximum level: "Examples are stock size and age composition, the vulnerability of incidental or unregulated stocks in a mixed-stock fishery, predator-prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Also important are ecological or environmental conditions that stress marine organisms, such as natural and manmade changes in wetlands or nursery grounds, and effects of pollutants on habitat and stocks" (NMFS 1998, 63 FR 24232).

[44] Thomson et al., "Modeling the Consequences," 1806-1819: "The Commission for the conservation of Antarctic Marine Living Resources (CCAMLR) takes the needs of krill into account in an indirect manner when recommending the annual krill catch limit. This is done using a single species model to estimate the size of the krill population (relative to its pre-exploitation size) after a 20-yr period of harvesting at a given intensity. The level of harvesting intensity is adjusted until the median krill spawning biomass is predicted to be 75% of its median pristine size."

[45] Richard L. Merrick, "Current and Historical Roles of Apex Predators in the Bering Sea Ecosystem," *Journal of Northwest Atlantic Fisheries Science* 22 (1997): 343-355.

[46] Ford Wilke and Karl W. Kenyon, "Notes on the Food of Fur Seal, Sea-Lion, and Harbor Porpoise," *Journal of Wildlife Management* 16 (1952): 396-397.

[47] David S. Jordan and Barton W. Evermann, *American Food and Game Fisheries, A Popular Account of All the Species Found in America North of the Equator* (Garden City, NY: Doubleday, Page and Co., 1902).

[48] Hiroshi Kajimura, "A Review of Fishery Resources and Commercial Catch of Fish Important to Northern Fur Seals," in *Background Papers Submitted by the United States to the 27th Annual Meetings of the Standing Scientific Committee of the North Pacific Fur Seal Commission, Moscow, March 29-April 9, 1984*, comp. National Marine Mammal Laboratory (Washington, DC: NMFS).

[49] Elizabeth H. Sinclair, George A. Antonellis, and Bruce W. Robson, et al., "Northern Fur Seal, *Callorhinus ursinus*, Predation on Juvenile Walleye Pollock, *Theragra chalcogramma*," in *Ecology of Juvenile Walleye Pollock, Papers from the workshop "The Importance of Prerecruit Walleye Pollock to the Bering Sea and North Pacific Ecosystems*," eds. Richard D. Brodeur, Patricia A. Livingston, and Thomas R. Loughlin, et al., NOAA Technical Report NMFS 126 (Washington, DC: U.S. Department of Commerce, 1996).

[50] Bruce W. Robson, "The Relationship Between Foraging Areas and Breeding Sites of Lactating Northern Fur Seals, *Callorhinus ursinus*, in the Eastern Bering Sea" (master's thesis, University of Washington, 2001).

[51] NPFMC, *Final Environmental Impact Statement for the Bering Sea/Aleutian Islands Groundfish Fishery Management Plan* (1981).

[52] Lloyd F. Lowry, Donald G. Calkins, and Gordon L. Swartzman, et al., *Feeding Habits, Food Requirements and Status of Bering Sea Marine Mammals*, (Anchorage: NPFMC, 1982), 148.

[53] NMFS, *FMP BiOp*, 185.

[54] Water has 24 times the heat conductivity of air.

[55] NMFS, *Endangered Species Act Section 7 Consultation—Steller Sea Lion Final Biological Opinion and Incidental Take Statement, Appendix A to the Final Supplemental Environmental Impact Statement for Steller Sea Lion Protection Measures* (2001), 51 [hereafter cited as *RPA BiOp*].

[56] Committee on the Bering Sea Ecosystem, NRC,*The Bering Sea Ecosystem* (Washington: National Academy Press, 1996), 145, Table 4.18.

[57] NMFS, *Final PSEIS*, 3.8-23; 4.5-232.

[58] NMFS, Endangered Species Act Section 7 Consultation—Biological Opinion Considering: Authorization of BSAI Groundfish Fisheries Based on TAC Specifications Recommended by the North Pacific Fishery Management Council for 1999; and Authorization of GOA Groundfish Fisheries Based on TAC Specifications Recommended by the North Pacific Fishery Management Council for 1999 (1998) [hereafter cited as *TAC BiOp*].

[59] James N. Ianelli. Steve Barbeaux, and Gary Walters, et al., "Eastern Bering Sea Walleye Pollock Stock Assessment," in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region as Projected for 2005-2006,* comp. The Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (NPFMC: Anchorage, 2004) [hereafter cited as *2004 EBS SAFE*].

[60] Rob Channell and Mark V. Lomolino, "Dynamic Biogeography and Conservation of Endangered Species," *Nature* 403 (2000): 84-85.

[61] Ibid.: "These apparently exceptional results and the more general tendency for persistence along the periphery indicate that range contraction is strongly influenced by anthropogenic extinction forces (for example, habitat degradation, biocides and introduced species) which render historical density patterns irrelevant. Populations that persist the longest are those last affected by the contagion-like spread of extinction forces; that is, those along the edge of the range, on an isolated and undisturbed island, or at high elevations."

[62] Committee on the Bering Sea Ecosystem, NRC, *The Bering Sea Ecosystem* (Washington: National Academy Press, 1996).

[63] Kenneth W. Pitcher, Donald G. Calkins, and Grey W. Pendleton, "Reproductive Performance of Female Steller Sea Lions: An Energetics-Based Reproductive Strategy?" *Canadian Journal of Zoology* 76 (1998): 2075-2083.

[64] NMFS, *TAC BiOp;* NMFS, *RPA BiOp;* NMFS, *FMP BiOp.*

[65] NMFS, *FMP BiOp,* 175.

[66] Although the closure of the Bogoslof Island portion of sea lion critical habitat to pollock fishing in 1992 was instituted as part of an international pollock treaty for the central Bering Sea (due to plummeting pollock abundance), it is generally included as one of the sea lion mitigation measures adopted by fisheries officials.

[67] *Endangered Species Act,* Sec. 3(5)(A)(i).

[68] NMFS, "Final Rule Designating Steller Sea Lion Critical Habitat [SSC HC]," *Federal Register* 58, no. 65 (1993), 45270-71: "These sites were selected because of their geographic location relative to Steller sea lion abundance centers, their importance as Steller sea lion foraging areas, their present or historical importance as habitat for large concentrations of Steller sea lion prey items that are essential to the species survival, and because of the need for special consideration of Steller sea lion prey and foraging requirements in the management of the large commercial fisheries that occur in these areas."

[69] NMFS, "Final Rule Designating," 45271.

[70] NMFS, *Draft Environmental Assessment/Regulatory Impact Review for Amendment 25 to the Fishery Management Plans of the Gulf of Alaska and Amendment 20 to the FMP of the Bering Sea and Aleutian Islands, Proposed Prohibition to Groundfish Trawling in the Vicinity*

of Gulf of Alaska and Bering Sea and Aleutian Islands Steller Sea Lion Rookeries (1991): "Available data indicate that 10 nm zones would not be sufficient to cover feeding trips of animals during the winter, females without pups throughout the year, and some feeding trips of postpartum females during the breeding season."

[71] NMFS, *Draft Environmental Assessment/Regulatory Impact Review for the Emergency Rule to Implement Reasonable and Prudent Steller Sea Lion Protection Measures in the Pollock Fisheries of the Bering Sea and Aleutian Islands Area and the Gulf of Alaska (2000)*, 90 [hereafter cited as *2000 Draft EA/RIR*].

[72] NMFS, NPFMC, and ASFC, *Draft Environmental Assessment/Regulatory Impact Review/IRFA for Inshore/Offshore-3, Amendments 51/51 to the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (1998) [hereafter cited as *1998 Inshore/Offshore EA/RIR*].

[73] Ibid.: "Pollock removals from critical habitat during the first part of the year increased from negligible levels in the late 1970s to over half a million mt in the mid-1990s. Pollock removals from critical habitat were less than 50,000 mt annually during the first quarters of 1977-1985..."

[74] Karl W. Kenyon and Dale W. Rice, "Abundance and Distribution of the Steller Sea Lion," *Journal of Mammalogy* 43 (1962): 68-75.

[75] Committee on the Bering Sea Ecosystem et al., *The Bering Sea Ecosystem*, 145, Table 4.18.

[76] Daniel Hennen, "Associations Between the Alaska Steller Sea Lion Decline and Commercial Fisheries," *Ecological Applications* 16 no. 2: 704-717.

[77] NMFS, *Revised Final Reasonable and Prudent Alternatives for the Pollock Fisheries of the Bering Sea and Aleutian Islands and Gulf of Alaska with Supporting Documentation* (1999), 17 [hereafter cited as *1999 Revised Final RPA*]: "In the [3 December 1998] Opinion, NMFS concluded that it would be reasonable to expect this competition to appreciably diminish the value of critical habitat for both the survival and recovery of the Steller sea lion, and appreciably reduce their likelihood of survival and recovery in the wild."

[78] NMFS, *FMP BiOp,* 159

[79] NMFS, *2001 Draft PSEIS*, 4.2-14.

[80] The moratorium on directed pollock fishing in the Bogoslof District (1993) and Aleutian Islands (1998) due to low pollock biomass encompassed an additional 118,760 km^2 (30%) of sea lion critical habitat.

[81] The pollock fishery typically catches two-thirds to three-quarters of the annual TAC in the southeastern Bering Sea (i.e., southeast of the 170ºW line) between Unimak Pass and the Pribilof Islands. A requirement to apportion a significant amount of pollock TAC to the west of 170ºW (i.e., northwest of the Pribilof Islands) was opposed by the pollock industry and NMFS never implemented this recommendation.

[82] NMFS, *1999 Revised Final RPA*.

[83] NMFS, *2000 Draft EA/RIR*, 90.

[84] The *1998 Inshore/Offshore EA/RIR* (NPFMC et al., 1998) highlighted the dramatic growth in the first quarter roe pollock fishery as well as its concentration in the pelagic foraging habitat of the Sea lion Conservation Area (SCA) between Unimak Island and Islands of the Four Mountains: "Pollock removals from critical habitat during the first part of the year increased from negligible levels in the late 1970s to over half a million mt in the mid-1990s. Pollock removals from critical habitat were less than 50,000 mt annually during the first quarters of 1977-1985..."

[85] Judge's Order, *Greenpeace v. NMFS*.

[86] Ibid.

[87] NMFS, *FMP BiOp*, 289: "This competitive interaction, occurring at the global, regional, and local scales has been shown to jeopardize the continued existence of Steller sea lions by interfering with their foraging opportunities for the three major prey species resulting in reduced reproduction and survival."

[88] Ibid., 271: "The fisheries effects that give rise to these determinations [jeopardy/adverse modification] include both large scale removals of Steller sea lion forage over time, and reduced availability of prey on the fishing grounds at scales of importance to individual foraging Steller sea lions, particularly in critical habitat."

[89] Ibid., 264-265.

[90] Ibid., 290.

[91] Ibid., 225.

[92] Ibid., 259

[93] Representatives from the Plaintiff organizations were not invited to sit on the committee.

[94] NMFS established an arbitrary and low “jeopardy bar” for the RPA committee: protect 50% of critical habitat area, 50% of non-pup population, and 75% of the pup population on rookeries. After debate and negotiations among industry sectors, the NPFMC’s RPA committee concluded that the proposed RPA plan would “protect” 52% of critical habitat, 79% of the non-pups, and 80% of the pups (on rookeries).

[95] NMFS, *Supplement to the Endangered Species Act Section 7 Consultation - Biological Opinion and Incidental Take Statement of October 2001* (2003), 11 [hereafter cited as *Supplemental BiOp*].

[96] NMFS, *RPA BiOp*, 139.

[97] Ibid., 143.

[98] Ibid., 143.

[99] Ibid., 143.

[100] Judge’s Order, *Greenpeace v. NMFS*, p. 7, December 12, 2002.

[101] NMFS, *Supplemental BiOp* (2003), 19: “There may be a transition period in the fall that is important for younger animals, particularly those starting their second year. The fall would also be a period of transition for adult females; not only would they be nursing a pup (which would be about 5 months old), but they…are also likely to be pregnant, and therefore have high energetic demands.”

[102] Ibid., Figs III-4, 5, 6, 7. See also: NMFS, *Alaska Region Inseason Management Report for 2004* (2004).

[103] Ibid., Fig. 7.

[104] NMFS, *RPA BiOp*, 172.

[105] NMFS, *Supplemental BiOp,* 24, Tables III-2, 4.

[106] Ianelli et al., *2004 EBS SAFE.*

[107] NMFS, Draft Environmental Assessment/Regulatory Impact Review for a Regulatory Amendment to Implement Reasonable and Prudent Steller Sea Lion Protection Measures in the Pollock Fisheries of the Bering Sea/Aleutian Islands and Gulf of Alaska (1999), Tables 3-1 and 3-4 [hereafter cited as *1999 Draft EA/RIR*].

[108] NMFS, *Final PSEIS* (2004), 4.5-232.

[109] Ibid., App. F, F-2-16.

[110] NMFS, *2004 EBS SAFE*.

[111] Martin Dorn, Steven Barbeaux, and Sarah Gaichas, et al., “Assessment of Walleye Pollock in the Gulf of Alaska*,*” in *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska,* comp. The Plan Team for the Groundfish Fisheries of the Gulf of Alaska (NPFMC: Anchorage, 2004).

[112] NMFS, *Final PSEIS*, App. F, F-2-19.

[113] NMFS, *Supplemental BiOp*, 24, Table III-4, Fig. III-3.

[114] Ibid., 24.

[115] Ibid., 24.

[116] Kenyon and Rice, “Abundance and Distribution,” 223-233. See also: Kenyon and Rice, Pribilof Islands field notes, 1960, cited Table 2.

[117] Richard D. Brodeur, Matthew T. Wilson, and Jeffrey M. Napp, et al., “Distribution of Juvenile Pollock Relative to Frontal Structure Near the Pribilof Islands, Bering Sea,” in *Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems*, Alaska Sea Grant Report AK-SG-97-01 (Fairbanks, Alaska: University of Alaska, 1997), 573-589: “These fronts may be up to approximately 10 km wide in some areas and exhibit elevated abundances of phytoplankton, zooplankton, and micronekton (Coyle and Cooney 1993; Napp et al. 1995; Decker and Hunt 1996) compared to those in the region seaward of the front. This elevated biomass attracts many mobile predators such as seabirds to these frontal regions (Kinder et al. 1983, Coyle et al. 1992, Decker and Hunt 1996).” See also: Stabeno et al. 1999.

[118] Anne E. York and James R. Hartley, “Pup Production Following Harvest of Female Northern Fur Seals,” *Canadian Journal of Fisheries and Aquatic Sciences* 38 (1981): 84-90.

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[124] NMFS, *Conservation Plan for the Northern Fur Seal*, viii.

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[126] Towell, *Memorandum for the Record*.

[127] Bruce W. Robson, ed., *Fur Seal Investigations, 2000-2001*, NOAA Technical Memorandum NMFS-AFSC-134 (Washington, DC: Alaska Fisheries Science Center, U.S. Department of Commerce, and NOAA, et al., 2002), 26, Fig. 9.

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[129] Daniel P. Costa, John P. Croxall, and Callan D. Duck, "Foraging Energetics of Antarctic Fur Seals in Relation to Changes in Prey Availability," *Ecology* 70 (1989), 596-606.

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[132] Committee on the Bering Sea Ecosystem et al., *The Bering Sea Ecosystem*, 149.

[133] NMFS, *FMP BiOp,* 81.

[134] NMFS, *Endangered Species Act Section 7 Consultation—Biological Opinion Considering: Authorization of an Atka Mackerel Fishery Under the BSAI Groundfish Fishery Management Plan between 1999 and 2002; Authorization of a Walleye Pollock Fishery Under the Bering Sea-Aleutian Island Groundfish Fishery Management Plan between 1999 and 2002; and Consideration of a Walleye Pollock Fishery Under the Gulf of Alaska Groundfish Fishery Management Plan Between 1999 and 2002*, 45.

[135] Arliss J. Winship, "Growth and Bioenergetic Models for Steller Sea Lions (*Eumetopias jubatus*) in Alaska," (master's thesis, University of British Columbia, 2000), 90- 93.

[136] Jordan and Evermann, *American Food and Game Fisheries*.

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[138] David S. Jordan, Leonard Stejneger, and Frederic A. Lucas, et al., *Second Preliminary Report of the Bering Sea Fur Seal Investigations* (Washington, DC: Government Printing Office, 1898), 30.

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[148] NMFS, *2001 Draft PSEIS, 2003 Draft PSEIS, Final PSEIS*.

[149] NMFS, *Final PSEIS*, App. A, 4.5-230.

[150] See: Kajimura 1984; Loughlin et al. 1987; Goebel et al. 1991; Robson 2001.

[151] BS/AI and GOA Plan Teams, *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions* (Anchorage: NPFMC, 2001), App. C, p.101, Fig. 6 [hereafter cited as *2001 SAFE*].

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[163] NMFS, *2003 Draft PSEIS*, 3.2-6.

[164] National Research Council, *Sustaining Marine Fisheries*, Committee on Ecosystem Management for Sustainable Marine Fisheries (Washington, DC: National Academy Press, 1999).

[165] NMFS, *2001 Draft PSEIS*, 19.

[166] NMFS, *2003 Draft PSEIS*, F-3-34.

[167] National Research Council, *Sustaining Marine Fisheries*.

[168] NMFS, *2001 Draft PSEIS*; NMFS, *2003 Draft PSEIS*; NMFS, *Final PSEIS*.

[169] NMFS, *2003 Draft PSEIS,* 10.

[170] National Research Council, *Sustaining Marine Fisheries*.

Bottom trawler *Defender* out of Rockland, Maine, leaves the harbor at St. Paul Island © 2006 Todd Warshaw/Greenpeace USA.

SHORTCOMINGS OF THE FEDERAL FISHERIES LAW AND INITIATIVES FOR ECOSYSTEM-BASED MANAGEMENT:

REDEFINING SUSTAINABILITY IN AN ECOSYSTEM CONTEXT

The Magnuson-Stevens Act is also known as the *Sustainable Fisheries Act of 1996*. However, the use of "sustainable" is misleading — the only mention of the word in the statute is to "maximum sustainable yield" (MSY).[1] The MSA is focused on maximizing resource utilization ("harvest"); sustainability is defined in terms of economic benefits for fisheries, not stewardship of natural ecosystems.[2]

NMFS asserts that the North Pacific groundfish fisheries for pollock and other species are managed "conservatively," according to the statutory yardstick of MSY. Whether the single-species standard of sustainability in the federal fisheries law is adequate to safeguard the long-term viability of the North Pacific ecosystems, native species, their food webs and habitats lies at the heart of the debate over the pollock fisheries. In other words, are yield-maximizing goals for single-species fisheries sustainable in an ecosystem context, and consistent with societal goals for ocean stewardship? This question has vexed the NPFMC, the scientific community, the public, and the courts for over a decade:

> *Fundamental conflicts between the usual goals of maximizing yields in marine fisheries management and the goals of the Endangered Species Act, Marine Mammal Protection Act, and the National Environmental Policy Act remain unresolved even at the federal level in the National Marine Fisheries Service, as illustrated by the present groundfish management by the North Pacific Fishery Management Council, which does not explicitly orient management to provide additional food resources for the threatened Steller sea lion or for other declining marine mammals and seabirds in the Bering Sea and Gulf of Alaska ecosystems.*[3]

The roots of this conflict lie in the very different conceptions of "conservation and management" in the federal fisheries law and environmental laws. The Magnuson-Stevens Act defines "conservation and management" in terms of maintaining food supply and other "products" — protecting the marine environment is only important to the extent necessary to support fisheries' objectives.[4] The objectives of the MMPA and ESA, on the other hand, are to foster healthy populations of marine mammals and to protect threatened or endangered species, respectively, in part by protecting the ecosystems and habitats on which they depend.[5]

The MSA definition of conservation and management states the intent to avoid "irreversible or long-term adverse effects on fishery resources and the marine environment,"[6] and the National Marine Fisheries Service emphasizes the need for ecosystem approaches to managing marine fisheries to fulfill the MSA mandates to conserve essential fish habitat of managed species.[7] Nevertheless, the MSA's conception of fish as food crop and economic opportunity ignores the fact that fish are wildlife and members of complex ecological communities. It follows that the management priority at the council level is resource utilization, consistent with the MSA National Standards. The burden of proof has been on advocates of greater ecosystem protection to demonstrate that constraints on fishing are justified. The management bias consistently avoids finding harm, largely for economic reasons, from fisheries activities even when the evidence suggests otherwise.[8]

In the context of the Alaska pollock fisheries, perhaps the clearest examples of how the management system errs on the side of the fisheries in the face of uncertainty are seen in two areas. First, the fishery managers' response to needs of declining pollock predators, such as the Steller sea lion or northern fur seal, favors fisheries. Second, there are no protected areas where pollock spawn in the Bering Sea and Gulf of Alaska; in fact these areas are targets of the trawl fleet in the winter spawning season. In both cases the operating assumption is that until proven otherwise, current levels of fishing have no significant adverse impacts, and the burden of proof to justify constraints on fishing is very high. Even when scientific evidence of adverse effects on the food web or habitat is raised, it is subject to dispute and the economic interests in the council process exploit uncertainties to weaken or defeat management measures that constrain fishing. If the MSA reversed this burden, it would be incumbent upon the fisheries to prove they were not adversely impacting trophic relationships, community structure, marine mammals, or the pollock stocks before the managers authorized fishing at such massive levels.

The difficulties of providing adequate protection to the pollock themselves and to dependent species in the pollock food web illustrate the obstacles to achieving ecosystem-based management under the MSA. The ways in which the existing law does not facilitate an ecosystem-based approach include:

- myopic focus on fisheries and commerce;
- narrow single-species scope of overfishing criteria based on MSY;
- discretionary habitat conservation mandate;
- lack of explicit ecosystem conservation objectives;
- lack of recognition of the precautionary principle; and
- pervasive influence of the fishing industry in the decision-making process of the regional fishery management councils.

THE RECENT COURT-ORDERED PROGRAMMATIC NEPA REVIEW ENDORSED ECOSYSTEM-BASED MANAGEMENT BUT DID NOT IMPLEMENT IT IN THE FISHERY MANAGEMENT PLANS

Prior to 1998, NMFS had not conducted a comprehensive review of the environmental impacts of the federal fishery management plans (FMPs) for Alaska groundfish fisheries since the original environmental impact statements (EIS's) were prepared for the Gulf of Alaska in 1979 and Bering Sea/Aleutian Islands in 1981, despite dramatic changes in the composition and conduct of the fishing fleets, status of individual fish and shellfish stocks, and marine wildlife populations.

The plaintiffs in *Greenpeace v. NMFS* asserted that NMFS, by failing to review the environmental impacts of these fisheries, failed to satisfy the NEPA standard of review of the direct, indirect, and cumulative impacts of the fishery FMPs.[9] The FMPs as a whole, not the setting of the annual catch limits, were the federal actions challenged by the plaintiffs.

In 1999, the U.S. District Court in Seattle agreed with Greenpeace that the National Environmental Policy Act requires NMFS to assess the cumulative effects of management actions since the original environmental impact statements were prepared for the Gulf of Alaska FMP (1976–78) and Bering Sea/Aleutian Islands FMP (1981), as represented in the 60+ amendments to both FMPs in the years since NMFS prepared those first environmental impact statements.[10] The Court ruled that "NEPA does not permit NMFS to continue making individually minor but collectively significant changes to the FMPs without preparing an SEIS [Supplemental Environmental Impact Statement] analyzing these changes," adding:

> *The Court has no doubt that the vast changes to the FMPs have reached the threshold of 'cumulatively significant impact on the environment,' thereby requiring preparation of an SEIS addressing these vast changes. For the same reasons, NMFS cannot then break the FMPs down 'into small component parts' by analyzing only the setting of TAC levels rather than these FMPs in their entirety. The Court therefore concludes that NEPA's cumulative effects provision requires a programmatic analysis of the FMPs in their current form.*[11]

As described by NMFS, the North Pacific FMPs state the NPFMC's goals and objectives for managing the fisheries; they constitute the framework designed to achieve specified management goals for a fishery.[12] The groundfish resources off Alaska have been managed principally to maximize economic benefit, as expressed in the four specific management objectives of the original 1981 Bering Sea/Aleutian Islands FMP.[13]

The FMPs have evolved since their inception, as reflected in the 80+ FMP amendments and other regulatory changes adopted by the NPFMC to address the myriad unintended consequences and impacts that have flowed from the original policy framework. These amendments require: (1) target species protection, (2) bycatch control, (3) the social and economic well-being of domestic resource users, (4) marine mammal and seabird protection, and (5) habitat protection.[14] Despite incremental changes to the FMPs, however, maximizing positive economic benefits of the fisheries remains the priority of management in the North Pacific,[15] based on MSY for single species, as set out by the MSA.[16]


Fishing boats, Kodiak, Alaska © 2006 Todd Warshaw/Greenpeace USA

FISHERY MANAGEMENT PLANS

A fishery management plan (FMP) is a plan to achieve specified management goals for a fishery, as mandated by the Magnuson-Stevens Act. The FMP sets priorities, defines goals, and specifies guidelines and rules to achieve management goals. Under the Magnuson-Stevens Act, eight regional fishery management councils, including the North Pacific Fishery Management Council, have the responsibility for drafting federal fishery management plans and amendments to those plans.

What is the overarching management goal that informs and guides council development of FMPs and regulatory amendments? NMFS states that the broad policy goal of FMPs is to maximize yield on a sustainable basis, as stated in the Magnuson-Stevens Act.[17] According to NMFS, other policy objectives of the North Pacific FMPs include:

- **increasing economic benefits to the nation;**
- **reducing bycatch and discards;**
- **increasing economic benefits to Alaska coastal communities;**
- **protecting target groundfish species;**
- **protecting non-target species;**
- **protecting threatened or endangered species; and**
- **protecting habitat.[18]**

However, fisheries objectives and the business of approving fishery specifications for the next year overshadow attempts to address ecosystem considerations. The FMP policy priorities emerged over time as a result of crises and pressures to which the NPFMC reacted as issues occupied the public spotlight. Increasing economic benefits to the nation and developing the fisheries have been the NPFMC's intended priorities throughout this period, while issues such as crab or marine mammal conservation, bycatch reduction, and habitat conservation forced their way onto the list. The current FMPs could be viewed as an attempt to reconcile the tug-of-war of competing goals and objectives, but under the MSA the balance between competing uses tilts in favor of the fishing industry.

The court also concluded that the need for a broad, programmatic analysis of the FMPs "leads directly to its conclusion that the range of alternatives considered was inadequate" because the narrow range of alternative TAC levels in the SEIS did not help decisionmakers assess "whether the fisheries should continue to be conducted under the current structure of the FMPs, or whether other alternatives would be more beneficial."[19]

In the Final Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement (PSEIS), NMFS stated:

> *The management approach and the objectives in the Preferred Alternative reflect a conservative, precautionary approach to ecosystem-based fisheries management, and communicate a policy direction for the future…The PA incorporates ecosystem-based management principles into a management approach that recognizes the need to both promote sustainable fisheries and protect fishery-dependent communities.*[20]

However, in the PSEIS, NMFS acknowledges that the Preferred Alternative fishery management plan only replaces the existing policy statement with a new one, and does not entail new management measures implementing the policy statement.[21]

Any specific changes in the fishery management regulations under the fishery management plans are discretionary and will only emerge as time, staff resources, and the politics of the council process permit. NMFS makes clear in the Alaska Groundfish Fisheries PSEIS that the North Pacific Fishery Management Council possesses the discretionary decision-making authority to implement the revamped FMP policy.[22] Thus despite the self-interested viewpoint of many council members, the NPFMC is to be the arbiter of how future tradeoffs will be weighed in complying with an FMP policy that contains many competing goals and objectives, of which "ecosystem-based management" is only one.[23]

In other words, a decision-making body that is not representative of the broader public interest and that is biased heavily in favor of commercial utilization of the public resource for its own benefit will continue to make the tradeoffs between maximizing fish populations for fisheries and protecting the ecosystem. Moreover, if history is any guide, any decisions for greater ecosystem protection will come only after science has shown a clear need and justification for taking any particular suite of actions, in which case it could take decades of sustained research to provide the indisputable evidence for action that satisfies skeptical fishery constituents.

The goals and objectives for ecosystem-based management in the FMPs remain largely rhetorical, lacking any statutory force of law within the existing FMP framework. The recent evolution of the FMPs has tended toward "ecosystem-based" conservation and management approaches to address the problems of the original FMPs, and certain features of the current FMPs are "consistent with" ecosystem-based management. However, it is important to note that the tendency has not been systematic or codified in a formal framework of priorities that make "ecosystem-based" management explicit. Absent explicit direction in the Magnuson-Stevens Act, the council process operates in an ad-hoc way without a clear mandate to pursue, develop, and formalize this trend.

Houck asked: "Can people who clearly represent specific economic interests perform adequately as trustees of the public resources they use?"[24] The mismanagement of fisheries throughout the United States is an indictment of this 25-year experiment in self-regulation by the fishing industry under the Magnuson-Stevens Act. Under the existing law there is no effective "balance between competing uses" because the scales are tilted in favor of fishing and resource extraction.

As the U.S. Commission on Ocean Policy and other commissions have recommended, Congress must undertake basic reforms of the nation's ocean policy, the federal fisheries law, the fisheries decision-making process, and the regional council management system so that other public interests and societal goals are fairly represented in order to achieve a "balance between competing uses" of the ocean commons.

CURRENT INITIATIVES FOR ECOSYSTEM-BASED MANAGEMENT IN CONGRESS AND IN THE NORTH PACIFIC: INCREMENTAL PROGRESS OR JUST BUSINESS AS USUAL?

Section 406 of the Magnuson-Stevens Act of 1996 tasked NMFS with convening a panel to develop recommendations "to expand the *application* of ecosystem principles in fishery conservation and management activities."[25] The report to Congress of the Ecosystem Principles Advisory Panel (EPAP) recommended an ecosystem-based management approach for fisheries and identified a broad fishery conservation and management goal of maintaining the health and sustainability of exploited ecosystems.[26]

Although the NPFMC applies some of the EPAP's principles, goals, and policies, the Panel concluded that they are not applied comprehensively and systematically in any fishery management region, nor is there a clear mandate for this ecosystem approach. Thus the EPAP recommended that Congress mandate the development of an explicit "Fisheries Ecosystem Plan" (FEP) for ecosystems under the jurisdiction of the regional Fishery Management Councils.

Alaska's Senator Ted Stevens and the Bush administration have proposed Magnuson-Stevens Act reauthorization language authorizing a version of ecosystem-based management and fishery ecosystem plans. However, this proposed language would be unlikely to have any effect because FEPs would be discretionary and informational and essentially disconnected from FMPs.[27]

Senator Stevens has indicated that the intent of the Bush administration is to side-step explicit statutory definitions or requirements for ecosystem-based management, so as to avoid legal challenges by environmental groups. From a November 2005 article published in the *Fairbanks Daily News-Miner*:

> *Many scientists in recent years have argued that fishery managers should consider the effects that their decisions have on entire ocean ecosystems, not just individual fish species. A number of environmental groups have pushed to mandate ecosystem-based management in the Magnuson-Stevens Act reauthorization.*
>
> *[Senator] Stevens said Wednesday his bill goes halfway there.*
>
> *'I think we have mandated it. We've not narrowly defined it,' Stevens said.*
>
> *That's because defining ecosystem-based management in the law could offer environmental groups another way to challenge a federal agency's actions, he said.*[28]

NMFS offers no prospect of addressing ecosystem considerations except by continuing under the status quo. The intention, as stated by NMFS,

> *is to provide the Councils with broad policy guidance and clear authorization to address fisheries management from an ecosystem approach. Since the Councils have currently addressed ecosystem management to varying extents and in different ways, these MSA provisions will allow them to tailor approaches to address the specific needs of their regions. Additionally, this MSA proposal emphasizes the Councils' discretionary authority rather than mandating actions that, in some instances, may not be necessary or may exceed the current capabilities of ecosystem science.*[29]

As envisioned by NMFS, FEPs are largely informational in nature. They would function much as the current "Ecosystem Considerations" appendix in the annual North Pacific Stock Assessment and Fishery Evaluation (SAFE) reports — i.e., as a stand-alone compendium of ecosystem information that has little or no bearing on the recommendations of the single-species stock assessments and does not enter into the Council's considerations when approving fisheries regulations through the FMP process. Thus there is no explicit requirement to account for the ecological consequences of an MSY-based fishing strategy on food webs, and no procedure to make adjustments to single-species catch levels to account for predator-prey relationships or habitat impacts.

The predictable result of the Stevens-Bush administration approach is seen in the North Pacific Fishery Management Council's current debate over the shape and scope of an "Ecosystem Approach to Fisheries," including a preliminary proposal for an Aleutian Islands FEP. The NPFMC's advisory Scientific and Statistical Committee (SSC) has formulated a draft purpose statement:

> *The Council recognizes that an explicit Ecosystem Approach to Fisheries (EAF) is a desirable process for future management of the marine fishery resources in the Alaskan EEZ and therefore is a concept that it wishes to pursue and further implement. A primary component of an EAF is the development of ecosystem-based fishery planning documents, and*

the Council intends to move forward with such development on a pilot basis. The Council recognizes that the Aleutian Islands ecosystem is a unique environment that supports diverse and abundant marine life, and a human presence that is closely tied to the environment and its resources. The Council believes that in light of these features, EAF could be a useful guide for future fishery management decisions in the Aleutian Islands area.[30]

However, the intent of an Aleutian Islands FEP and its relation to the fisheries management plans or management decision-making process is unclear, as reflected in the SSC's question: "Does the Council intend for the FEP to dynamically guide fishery management actions, or rather to be a compendium of ecosystem knowledge?"[31]

Under current law, an Aleutian Islands FEP would have no regulatory authority over the fishery management plans: "Barring a change in statute, a FEP cannot authorize management measures, and such authority would remain vested in the FMPs."[32] In other words, the Aleutian FEP would be a stand-alone document or statement of intent separate from the fishery management plans and lacking statutory authority. Any effect the FEP might have on fishery management is at the discretion of the Council.

The preliminary proposal for an Aleutian FEP underscores the limitations of the incremental approach recommended in the Ecosystem Principles Advisory Panel report to Congress. At best, these are halting steps in the right direction that fall short of the mark. At worst, they represent tokenism and greenwashing to provide cover for industry marketing campaigns to sell Alaska pollock as a "green" fishery.

ECOSYSTEM-BASED FISHERIES MANAGEMENT: SHIFTING THE BURDEN OF PROOF FROM THE ENVIRONMENT ONTO THE FISHERIES

The goal of ecosystem-based fisheries management is to put ecosystem principles into *practice*, a desire also expressed in the MSA.[33] As framed by environmental organizations during the programmatic review of the North Pacific groundfish fishery management plans in 2001 and 2003, a basic intent of ecosystem-based management should be to resolve fundamental conflicts between the goal of maximizing yields in marine fisheries management and the goals of national environmental mandates in the Endangered Species Act, Marine Mammal Protection Act, and National Environmental Policy Act, among others.[34]

Versions of ecosystem-based management now under consideration at the federal and regional level would remain discretionary in terms of legal requirements and largely informational in terms of the fishery management decision-making process, requiring no explicit management actions. Ecosystem planning and management actions to address ecosystem impacts of fishing remain ancillary to the business of allocating fish and maximizing economic benefits.

Applicable conservation and fisheries laws provide for an ecosystem-based approach to the use of living marine resources. The existing MSA definition of "conservation and management" implicitly recognizes the importance of protecting marine ecosystems.[35]

The definition of "optimum yield" authorizes reductions in fishing levels from the theoretical maximum allowable level to account for ecological factors.[36] Furthermore, the MSA guidelines for essential fish habitat (EFH) conservation in the EFH final rule require an ecosystem approach, where possible, in determining EFH of a managed species.[37] More explicitly, the Marine Mammal Protection Act and Endangered Species Act mandate the conservation of ecosystems and habitats on which listed species depend.

However, the application of ecosystem principles under the MSA framework requires explicit direction and guidelines in the fishery management plans, which constitute the policy framework and accompanying regulations designed to achieve specified management goals for U.S. marine fisheries.[38] The Ecosystems Principles Advisory Panel concluded that existing federal FMPs are not sufficient to implement an ecosystem-based approach to fisheries management.[39] While the existing North Pacific FMPs have elements which are "consistent with" an ecosystem-based approach, there is no formal mandate or binding, non-discretionary requirement to address fishing impacts on marine ecosystems, including clearly stated goals and rules at the regulatory level to implement those objectives. Thus Congress should expand the existing MSA definition of fishery "sustainability" to address ecosystem considerations and objectives in the FMPs.[40]

In an ecosystem context, fishery sustainability may be understood as levels and methods of fishing that are compatible with explicitly stated FMP objectives for preserving the productivity, nutrient dynamics, habitats, trophic structure, species richness, and resilience of the natural ecosystem. Reflecting this understanding, NMFS broadly defines ecosystem approaches to fisheries management as the means "whereby management programs consciously account for and address: (1) all living resources within a specific marine area/ecosystem, including stocks targeted by fishing operations, non-target stocks, and the marine environment; and (2) all sources of environmental stress and factors influencing the ecosystem including fishing operations."[41]

In the absence of clear guidance and statutory requirements, however, fisheries managers can interpret an unspecified mandate to "account for and address" ecosystem considerations in any number of ways. This is why the U.S. Commission on Ocean Policy and Pew Oceans Commission called on Congress to fundamentally reform the federal fisheries management system, including a new national policy aimed at implementing an ecosystem approach for oceans and coasts and a complete overhaul of federal governance to guide and coordinate federal agencies whose activities affect the marine environment.[42]

A NEW WAY TO THINK ABOUT ALASKA'S FISH AND OCEANS[43]

The Alaska groundfish fisheries are managed to have the most fish available for the commercial fisheries. They are not managed to make sure that the commercial catch does not harm the ocean environment and the fish, marine mammals, and seabirds that share that environment. If the management strategy is not changed to be more protective of the whole ocean ecosystem, we may face collapses of fish stocks and other animals that rely on healthy fish populations. That would be devastating to the ocean environment, commercial fishermen, and Native villagers.

When figuring out how many fish can be caught, we must ensure that enough fish are left for marine mammals, seabirds, and other fish to eat. We also need to protect the ocean bottom and water quality so that fish and other animals have a healthy place to live. With these changes, we will continue to have opportunities to catch fish and enjoy the amazing wildlife of our nation's marine ecosystems for generations to come.

What needs to change?

Protect special areas from being damaged by fishing.

- **Stop the use of fishing gear that damages habitat.**
- **Reward fishermen who use less destructive fishing gear by letting them catch a bigger share of the fish.**
- **Don't fish in areas where fish reproduce.**
- **Don't fish in areas where corals and sponges live.**

Stop the waste of fish.

Set bycatch limits for each species in the North Pacific. When those limits are reached, prohibit further fishing on those species.

- Figure out how much bycatch is not being counted (this includes the number of corals, sponges, crabs, and shellfish that are damaged by fishing gear and left on the ocean bottom).
- Set and enforce penalties for exceeding allowed catch.
- Set up areas where no fishing is allowed because the bycatch is so high.

Set lower catch levels of fish.

- Reduce catch levels to leave more fish in the water as food for other fish, mammals, and birds. Currently, the management goal is to catch 60% of the adult fish from a population on average. Instead, the goal should be to leave more than half of the reproductive-age fish in the water. For instance, aim to catch no more than 25% of an individual fish stock.
- Lower catch levels to act as insurance against information that we don't know and to buffer against management mistakes in predicting how many fish there are.
- Set catch levels which consider specific life history characteristics of fish stocks (reproductive age, life span, etc.).
- Restrict where and when you can fish to avoid depleting fish stocks, even temporarily.

Increase research and monitoring.

- Review existing information and identify knowledge gaps to keep Alaska's oceans—including fish, wildlife, and birds—healthy.
- Map the ocean bottom and where fishing occurs.
- Identify areas where fish, mammals, and seabirds migrate.
- Test for contaminants in key fish, wildlife, and bird species that signal the overall health of the ocean system.
- Require observers to monitor how much and what is caught on all fishing boats.
- Require fisheries to prove their actions are not damaging the ocean environment before allowing them to fish.

Recognize traditional Alaska Native subsistence uses and cultural values of ocean resources.

- Develop co-management agreements for fish and marine mammals.
- Government researchers and Alaska Natives should cooperate to use traditional knowledge in designing research and study plans.
- Government researchers and Alaska Natives should cooperate to use traditional knowledge in monitoring and collecting data.
- Government should fund a program developed and administered by Native peoples to monitor the health of Alaska's coast and river systems.

THE OCEANS ALTERNATIVE

In 2003, as part of the public comment process in the programmatic evaluation of the environmental impacts of the groundfish fisheries, conservation organizations submitted their vision for an ecosystem-based approach for fisheries management in the North Pacific. This "Oceans Alternative" builds upon these recommendations in an effort to redefine sustainability in an ecosystem context and operationalize ecosystem-based management in the water. The Oceans Alternative would require managers to adopt a fishery ecosystem plan for each major ecosystem under NMFS jurisdiction, incorporating explicit principles, policies, guidelines, and regulations for ecosystem-based management into the FMPs. Under these plans, conservation and management are defined as rules designed to:

1. Protect, maintain, and restore healthy marine ecosystems, understood as ecosystems in which ecological processes, habitats, trophic levels, and productive capacity are comparable to an unexploited system, and the diversity of the native flora and fauna is preserved at the genetic, species, and community level.

2. Rebuild, restore, and maintain exploited fish stocks at high levels relative to an unfished condition in order to preserve the ecological relationships between the exploited, dependent, and related species in the food web.

3. Conserve fish and other wildlife habitats within a comprehensive plan for the protection of essential fish habitat of managed species, critical habitat of ESA-protected species, known important habitat of MMPA-protected species, and habitat of management-defined categories of non-target and unmanaged species.

4. Provide for commercial, recreational, and non-consumptive uses of the marine environment within the framework of 1-3.

5. Avoid irreversible or long-term adverse effects on fishery resources and the marine environment.

6. Transmit a legacy of healthy ecosystems to future generations.

Etnier urchin barrens © 2006 Michael Etnier/Greenpeace.

The Oceans Alternative FEP/FMP illustrates what fisheries management would look like if the burden of proof were shifted from the environment onto the fisheries. As such, the Oceans Alternative contrasts sharply with the version of ecosystem-based management offered by NMFS as the "Preferred Alternative" FMP in the court-ordered programmatic supplemental EIS on the groundfish fishery management plans.[44] While consistent with the recommendations of the U.S. Commission on Oceans Policy and others, the Oceans Alternative also contrasts sharply with the current proposals by Senator Stevens and the Bush administration.

KEY COMPONENTS OF A CREDIBLE FISHERY ECOSYSTEM PLAN

Credible fishery ecosystem plans must include several key components: target species management; spatial-temporal management of TACs; consideration of non-target species taken incidental to fishing; a habitat protection plan; a catch monitoring/observer program; a scientific research and monitoring plan; and native subsistence and co-management plans. These program areas are detailed below.

TARGET SPECIES MANAGEMENT: OVERFISHING IN AN ECOSYSTEM CONTEXT

Currently the North Pacific groundfish management plans define overfishing levels and sustainability with respect to maximum sustainable yield, a simplified production theory which regards any fish production above the level required to maintain spawning stock at a given target size as "surplus" for the fishery. To compensate for the ecological deficiencies of MSY, overfishing guidelines must be modified to account explicitly for:

- the roles of target species as prey for other fish, marine mammals, invertebrates, and birds;
- the unique life history characteristics;
- the habitat needs; and
- the scientific uncertainties that make target species vulnerable to conventional MSY levels of fishing mortality.

Fishing levels should be set in a precautionary manner to preserve ecological relationships between harvested, dependent, and related species. The TAC-setting process should contain procedures and requirements to reduce maximum allowable fishing levels under the conventional single-species MSY rules to an Optimum Yield (OY) level. The objective is to address both the cumulative effects of fishery-maximizing exploitation strategies that are designed to out-compete the other parts of the ecosystem and local-scale impacts of spatial or temporal concentration of fishery catches.[45] Fishery managers should reduce fishing for important forage species to more precautionary levels to maintain the forage base for predators at high levels of abundance relative to the unfished condition. The Convention for the Conservation of Antarctic Living Marine Resources (CCAMLR) has a harvest policy for important forage species such as krill (*Euphausia superba*) that allows the fishery to catch only 25% of the biomass in an effort to take the needs of predators into account.[46]

Uncertainty should be incorporated systematically into setting catch levels to account for measurement errors (surveys, fishery observer data), process errors (stock assessment model simulations), and extrinsic ecological and environmental factors that act on fish population dynamics in unknown and/or unpredictable ways. The overall approach reflects a policy objective to maintain a large margin of safety in recommending acceptable biological catches in an environment where uncertainty is all-pervasive and even the best available scientific information is frequently full of unknowns.

Killer whale in the Bering Sea. © 2006 Todd Warshaw/Greenpeace USA.

SPATIAL-TEMPORAL MANAGEMENT OF TACS

Fishery stock assessments do not assess the spatial distribution of stock biomass, the movement of fish over the course of the year, or the spatial and temporal effects of fishing. Acceptable biological catch levels (ABCs) are set at the area-wide scale of the "stock as a whole" and on a start-of-year basis,[47] but for economic reasons, fisheries concentrate effort in highly productive areas and times of high catch per unit of effort (CPUE). Concentrating fishing in space and time increases the risk of overfishing and adversely impacts reproductive success of target stocks, their habitats, and dependent and related species.[48]

To address these shortcomings, FMPs should include data and criteria for spatial and temporal management of TACs based on management objectives for target, non-target, and protected (ESA, MMPA) species, bycatch reduction, and habitat protection. Fishery managers should employ appropriate spatial-temporal measures as part of the management of each fishery, including:

- gear restrictions;
- gear closure areas;
- bycatch-triggered closure areas;
- no-take marine reserves; and
- other measures that address management objectives for conservation of species and habitats in the ecosystem.

The TAC-setting process should include procedures to evaluate the spatial-temporal dimensions of fishing impacts explicitly, recognizing the limits and imprecision of available information.

Stock assessments should

- include relevant data for spatial-temporal management of each target fishery, including maps of fishing effort and catches by areas and times of year using available Observer Program and/or vessel monitoring system location data;
- include information on the geographic and seasonal distribution of stock biomass from available resource surveys and other relevant data; and
- identify critical information gaps.

NON-TARGET ("BYCATCH") SPECIES TAKEN INCIDENTAL TO FISHING

Hundreds of species are caught and killed incidentally in U.S. fisheries in the pursuit of commercially valuable species. In the North Pacific, much of the non-target bycatch consists of species in the largest and least understood FMP species categories (e.g., "Other," "Forage," and "Non-specified" species) for which species-specific bycatch statistics are lacking because species-level identification is not required in the fishery Observer Program under the current FMPs.[49] In other regions of the country, where observer coverage on fishing boats is far lower or non-existent, little or no data are available to assess the impacts of bycatch for any species.

Bycatch limits are a principal tool for constraining bycatch of commercially valuable halibut, herring, salmon, and crab in the North Pacific. However, bycatch caps for a few "prohibited" species understate the full impacts of fisheries on non-target species and habitats. Bycatch caps

- do not account for the vast majority of non-target species caught, for which bycatch limits have not been determined;
- do not account for species that are crushed or maimed by trawl gear and left on the seabed;
- do not provide protection to seabed habitat from fishing gear disturbance and damage; and
- are costly and information-intensive to manage, requiring extensive independent survey and fishery observer data.

Reporting mechanisms that focus on the percentage of bycatch often understate the problem, particularly in the case of industrial fisheries like the pollock fishery, where bycatch has been a major concern for NMFS.[50] From 1998 to 2005, the pollock fishery was responsible for well over 90% of all salmon bycatch associated with the groundfish fisheries. This bycatch has increased dramatically in recent years, reaching a high in 2005 of over 700,000 salmon. The 2005 pollock fishery bycatch take included close to 75,000 chinook salmon, nearly three times the amount that would result in area closures if it had taken place in the narrowly defined Chinook salmon savings area. There are no limits to Chinook bycatch outside the savings area.

Fishing gear closure areas and marine reserves can serve as a cheaper and more effective conservation tool to reduce bycatch while protecting habitats and reducing or eliminating conflicts with foraging birds and mammals that congregate in these zones. Allocating fish to cleaner, lower-impact gear types should also be employed in conjunction with an integrated system of gear closure areas and marine reserves in order to reduce and avoid bycatch. A bycatch plan should reduce or eliminate bycatch of all non-target species, not simply seek to reduce economic discards, as under the North Pacific's Improved Retention/Improved Utilization program for pollock and cod.[51]

HABITAT PROTECTION PLAN

Habitat conservation is a basic requirement of responsible oceans management and is essential for the health and sustainability of all species and ecosystems. An adequate habitat protection plan should:

- zone and delimit fishing gear use in the action area;
- provide comprehensive habitat protection of all major types of benthic and pelagic ocean habitat; and
- provide an integrated network of gear closure areas combined with marine reserves, understood as areas that are fully protected and free of exploitation.[52]

Before 1950, many areas of the ocean were unreachable using the vessels and gear of the day, and thus most marine fish populations enjoyed *de facto* refuges from fishing. Today there are no refuges from fishing unless managers designate areas as no-take reserves, based on goals for conserving species and habitats. Closure areas serve as protection for essential habitat types (spawning grounds, coral substrates, productive upwelling zones, designated critical/essential habitats of protected mammal and bird species), as hedges against scientific uncertainty, and as scientific control areas to facilitate learning and informed adaptive management. Within the areas protected by marine reserves, populations depleted by fishing typically rebound to much greater abundance than in areas left open to fishing. Fish populations within marine reserves can reestablish pre-fishing age and size structures, leading to dramatic increases in reproductive capacity which can help re-seed surrounding areas.

A review of scientific recommendations for the creation of large no-take marine reserves suggests that maximum conservation and fisheries benefits are derived from setting aside between 20 and 50% of the oceans as marine reserves. Some rare and vulnerable habitats may need 100% protection.

Habitat protection measures should employ a science-based approach while recognizing that the study of fishing effects on all habitat types will remain uncertain for the foreseeable future. Scientific uncertainty about the effects of fishing on marine habitats is no reason to delay habitat protection, rather a reason to increase it (see Scientific Research and Monitoring Plan below). This precautionary approach manages explicitly for habitat complexity now, while research on "essential" habitats continues.[53] Habitat protection measures can serve the cause of science and improve understanding by providing research control areas to study the effects of fishing while providing hedges against uncertainty and preserving options for the future.[54,55]

CATCH MONITORING/OBSERVER PROGRAM

Without fishery observer catch data and biological sampling for stock assessment purposes, fishery management has no way to enforce regulations or to monitor and assess fishery impacts. Therefore, observer coverage and Vessel Monitoring Systems should be required in all U.S. fisheries, as part of the cost of doing business. Improvements in identification and enumeration in all managed species categories should be prioritized and resources, including staff and funding, should be made available to accomplish those goals. An equitable funding mechanism should be developed to support a robust national Fishery Observer Program that accomplishes the goals and objectives of the MSA for total catch measurement and other data needs "necessary for the conservation, management, and scientific understanding of any fisheries under the Council's jurisdiction."[56] A top national priority should be implementation of a comprehensive observer program, including program design, objectives, sampling protocols, and methods for improving data collection.

SCIENTIFIC RESEARCH AND MONITORING PLAN

The Oceans Alternative science and research approach is science-based but recognizes that research is not a panacea and that, in most cases, more research will not resolve scientific uncertainty about marine ecosystems. The need for more information should not, therefore, excuse further delay of precautionary measures to conserve ecosystem components while research continues. Scientific uncertainty about the effects of fishing on ecosystems is not a reason to delay environmental protection or ecosystem-based management, but rather a reason to increase it.[57] Basic precautionary principles guide this ecosystem-based management approach to science, research, and uncertainty:

- The management system is science-based but must have realistic expectations about the ability of scientific research to yield conclusive results or provide unequivocal management advice.
- The burden of scientific proof must be shifted from the environment to fisheries; scientific uncertainties about the effects of fishing on marine ecosystems are reasons for more, not less, environmental protection.
- Action must be taken in the face of uncertainty, guided by policy priorities and values in the FMPs that recognize high risks of error and leave large margins for safety.
- Marine reserves can serve as control areas to study the effects of fishing while providing hedges against uncertainty and preserving options for the future.

NATIVE SUBSISTENCE AND CO-MANAGEMENT PLANS

Upholding U.S. treaty obligations and protecting traditional Native American subsistence uses and cultural values of living marine resources should be part of a fishery ecosystem plan.

- Co-management agreements should be developed to address adverse impacts of commercial fisheries on species and habitats of cultural and economic significance.
- Cooperative research designed to utilize traditional knowledge, including monitoring and data-gathering capabilities, should be developed.

NOTES

SHORTCOMINGS OF THE FEDERAL FISHERIES LAW

[1] Burr Heneman, "Federal Fishery Laws: New Model Needed to Sustain Fisheries and Ecosystems," in *Managing Marine Fisheries in the United States, Proceedings of the Pew Oceans Commission Workshop on Marine Fishery Management* (Arlington, VA: Pew Oceans Commission, 2002), 1-5.

[2] J. Baird Callicott, *Beyond the Land Ethic: More Essays in Environmental Philosophy* (Albany, NY: State University of New York Press, 1999), 369.

[3] Committee on the Bering Sea Ecosystem, Polar Research Board, and Commission on Geosciences, Environment and Resources, et al., *The Bering Sea Ecosystem* (Washington, DC: National Academy Press, 1996), 24.

[4] *U.S. Code* 16 § 1802 3(29).

[5] The MMPA , Sec. 3(2), for instance, defines "conservation and management" to mean "the collection and application of biological information for the purposes of increasing and maintaining the number of animals within species and populations of marine mammals at their optimum sustainable population . . ." (*U.S. Code* 16 § 1632). MMPA Sec. 2(6) states that the primary management objective "should be to maintain the health and stability of the marine ecosystem" (*U.S. Code* 16 § 1361). Similarly, the ESA defines the terms "conserve," "conserving," and "conservation" to mean "the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary." ESA Sec. 3(3). Sec. 2(b) states the purposes of the ESA: "[T]o provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved . . .etc."

[6] *Magnuson-Stevens Fishery Conservation and Management Act*, Public Law 94-265.

[7] 62 FR 66531 (Interim EFH Regulations): "Even though traditional fishery management and FMPs have been mostly based on yields of single-species or multi-species stocks, these regulations encourage a broader, ecosystem approach to meet the EFH requirements of the Magnuson-Stevens Act."

[8] Paul K. Dayton, Mia J. Tegner, and Peter B. Edwards, et al., "Sliding Baselines, Ghosts, and Reduced Expectations in Kelp Forest Communities," *Ecological Applications* 8 (1998): 309-322.

[9] Civ. No. C98-0492Z.

[10] The number of amendments is over 80 today.

[11] *Greenpeace v. NMFS*, 55 F. Supp. 2d 1248, 1274 (W.D.Wa. 1999).

[12] NMFS, *2001 Draft PSEIS*, 2, App. G.

[13] NPFMC, *Final Regulatory Impact Review for the Bering Sea/Aleutian Islands Area Groundfish Fishery Management Plan of the North Pacific Council* (1981), 14-15.

[14] NMFS, *2001 Draft PSEIS*, 18-19, Table 6.

[15] Ibid., 2.

[16] Ibid., 43.

[17] NMFS, *Alaska Groundfish Fisheries Draft Programmatic Supplemental Environmental Impact Statement* (2001), 43 [hereafter cited as *2001 Draft PSEIS*].

[18] Ibid., 2-5.

[19] *Greenpeace v. NMFS*.

[20] Ibid., ES-47.

[21] NMFS, *Alaska Groundfish Fisheries Final Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2004) [hereafter cited as *Final PSEIS*]. *Final PSEIS* includes the following question and answer:

Q: "What specific management measures will be set in motion for implementation by the adoption of the preferred alternative?"

A: "None…If approved, the amendment would replace the old policy with a new policy statement. Specific regulations implementing that policy are not planned to be submitted with the new policy statement." (NMFS, *Final PSEIS*, ES-63.)

[22] NMFS, *Alaska Groundfish Fisheries Draft Programmatic Supplemental Environmental Impact Statement on the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans* (2003), I, 2-62 [hereafter cited as *2003 Draft PSEIS*].

[23] Ibid.

[24] Oliver A. Houck, "On the Law of Biodiversity and Ecosystem Management," *Minnesota Law Review* 81 (1997): 869.

[25] *U.S. Code 16* § 1882, Sec. 406. [Emphasis added.]

[26] Ecosystem Principles Advisory Panel (EPAP), *Ecosystem-Based Fishery Management: A Report to Congress by the Ecosystem Principles Advisory Panel* (Washington, DC: U.S Department of Commerce, NOAA, NMFS, 1999).

[27] NMFS, *Fact Sheet: Reauthorization of the Magnuson-Stevens Act. Issue: Fisheries Ecosystems* (2005), http://www.nmfs.noaa.gov/docs/msa2005/ecosystem_management.pdf.

[28] Sam Bishop, "Stevens Writes Bill to Prevent Overfishing," *Fairbanks Daily News-Miner*, November 17, 2005.

[29] NMFS, *Fact Sheet*.

[30] NPFMC, Discussion Items for Developing an AI Fishery Ecosystem Plan (2005).

[31] NPFMC, *Discussion Items*, 2.

[32] Ibid.

[33] *U.S. Code 16* § 1882, Sec. 406.

[34] Committee on the Bering Sea Ecosystem et al., *The Bering Sea Ecosystem*, 24.

[35] *U.S. Code 16* § 1802, Sec. 3(5). MSFCMA expresses the intent of conservation and management to avoid irreversible or long-term adverse effects on fishery resources and the marine environment.

[36] *U.S. Code 16* § 1802, Sec. 3(28).

[37] 67 FR 2377, Section 600.815 [iv][E]: "Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species. EFH must be designated for each managed species, but, where appropriate, may be designated for assemblages of species or life stages that have similar habitat needs and requirements."

[38] NMFS, *2001 Draft PSEIS*, 2.4, p. 2, App. G.

[39] EPAP, *Ecosystem-Based Fishery Management*, 27.

[40] *U.S. Code 16* § 1802, Sec. 3(28) defines MSY as "a rate or level of fishing mortality that jeopardizes the long-term capacity of a stock to produce maximum sustainable yield on a continuing basis..."

[41] NMFS, *Fact Sheet*.

[42] U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century. Final Report* (Washington, DC: 2004).

[43] Courtesy of Alaska Oceans Program.

[44] NMFS, *Final PSEIS*.

[45] NMFS 1998, 63 FR 24232. Concerning ecological factors, the National Standard Guidelines give the scientific advisors and managers wide latitude to reduce the allowable fishing rates from the theoretical maximum level: "Examples are stock size and age composition, the vulnerability of incidental or unregulated stocks in a mixed-stock fishery, predator-prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Also important are ecological or environmental conditions that stress marine organisms, such as natural and manmade changes in wetlands or nursery grounds, and effects of pollutants on habitat and stocks."

[46] R.B. Thomson, D.S. Butterworth, and I.L. Boyd, et al., "Modeling the Consequences of Antarctic Krill Harvesting on Antarctic Fur Seals," *Ecological Applications* 10 (2000): 1806-1819: "The Commission for the conservation of Antarctic Marine Living Resources (CCAMLR) takes the needs of krill into account in an indirect manner when recommending the annual krill catch limit. This is done using a single species model to estimate the size of the krill population (relative to its pre-exploitation size) after a 20-yr period of harvesting at a given

intensity. The level of harvesting intensity is adjusted until the median krill spawning biomass is predicted to be 75% of its median pristine size."

[47] NMFS, *2003 Draft PSEIS*, F-2-30.

[48] NMFS, *Final PSEIS*, 5-15, 16; PSEIS II, 4.5-280; Appendix F-2, 3, 4.

[49] NMFS, *2001 Draft PSEIS*; NMFS, *2003 Draft PSEIS*; NMFS, *Final PSEIS*.

[50] Richard L. Wilmot, *Efforts to Determine the Stock Origins of the Salmon Bycatch in the Bering Sea Groundfish Fishery*, NPFMC Salmon Workshop, April 4, 2006.

[51] The IR/IU program requires that the fisheries keep all pollock and Pacific cod caught unintentionally (e.g., they are the wrong age or size) and use them in some way. Frequently, IR/IU pollock is ground into fishmeal and sold. The IR/IU program reduces the fish that are simply thrown back into the ocean. These fish are not considered and reported as bycatch because they are retained and utilized, regardless of the fact that they were incidentally caught.

[52] National Research Council, *Sustaining Marine Fisheries*, Committee on Ecosystem Management for Sustainable Marine Fisheries (Washington, DC: National Academy Press, 1999).

[53] Peter J. Auster, Les Watling, and Alison Rieser, "Comment: The Interface Between Fisheries Research and Habitat Management," *North American Journal of Fisheries Management* 17 (1997): 591-595.

[54] Paul K. Dayton, Enric Sala, and Mia J. Tegner, et al., "Marine Reserves: Parks, Baselines, and Fishery Enhancement," 66 (2000): 617-634.

[55] Daniel Pauly, Villy Christensen, and Sylvie Guenettte, et al., "Towards Sustainability in World Fisheries," *Nature* 418 (2002): 689-695.

[56] *U.S. Code 16* § 1853 et seq.

[57] Auster et al., *Comment: The Interface*, 591-595.

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ACRONYMS

ABC	Acceptable biological catch
AI	Aleutian Islands
AFA	American Fisheries Act
BiOp	Biological Opinion
BS	Bering Sea
BS/AI	Bering Sea/Aleutian Islands
CDQ	Community Development Quota System
CH	Critical habitat
CPUE	Catch per unit of effort
EBM	Ecosystem-based management
EBS	Eastern Bering Sea
EEZ	Exclusive economic zone
EFH	Essential Fish Habitat
EIT	Echo Integration Trawl
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act
FEP	Fisheries Ecosystem Plan
FMP	Fishery Management Plan
GOA	Gulf of Alaska
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Act
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act
NESP	Northeast St. Paul Island
NFS	Native fish strategy (no definition in report)
NMFS	National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council
PI	Pribilof Islands
RPA	Reasonable and prudent alternative
SAFE	Stock Assessment and Fishery Evaluation
SCA	Sea lion Conservation Act
SEIS	Supplemental Environmental Impact Statement
SG	St. George Island
SSL	Steller sea lion
SWSP	Southwest St. Paul Island
TAC	Total allowable catch

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