A SUMMARY OF NEW SCIENTIFIC ANALYSIS

little fish BIG IMPACT

Managing a crucial link in ocean food webs

Summary of a report from the Lenfest Forage Fish Task Force

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Literature Cited

Pikitch, E., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., and Steneck, R.S. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.

Credits

Cover photo illustration: shoal of forage fish (center), surrounded by (clockwise from top), humpback whale, Cape gannet, Steller sea lions, Atlantic puffins, sardines and black-legged kittiwake.

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little fish
BIG IMPACT

Fisheries managers need to pay more careful attention to the special vulnerabilities of forage fish and the cascading effects of forage fishing on predators, according to the April 2012 report *Little Fish, Big Impact.* The report is from the Lenfest Forage Fish Task Force, a group of 13 preeminent scientists formed to provide practical advice on sustainable management.

Brief summary: Forage fish are small to medium-sized species that include anchovies, herring, menhaden, and sardines. Direct catch of forage fish makes up more than one-third of the world's marine fish catch and has contributed to the collapse of some forage fish populations. In the most comprehensive global analysis of forage fish management to date, the Task Force found that conventional management can be risky for forage fish because it does not adequately account for their wide population swings and high catchability. It also fails to capture the critical role of forage fish as food for marine mammals, seabirds, and commercially important fish such as tuna, salmon, and cod. The report recommends cutting catch rates in half in many ecosystems and doubling the minimum biomass of forage fish that must be left in the water, compared to conventional management targets. Even more stringent measures are advised when important biological information is missing.

Background and Methods

What are Forage Fish?

Forage fish are small to medium-sized species that include anchovies, herring, menhaden, and sardines. The Lenfest Forage Fish Task Force defines forage fish by their role in marine ecosystems (see Box).

TASK FORCE DEFINITION OF FORAGE FISH

- Forage species are the main path for energy to flow from the bottom level of the food web to the higher trophic levels. They feed mainly on plankton and serve as prey to other ocean life.
- Few species fill this trophic role, but they are the majority of the vertebrate biomass of marine ecosystems.
- These species retain their crucial role in the food web throughout their life span.
- They tend to have a relatively small body size, early maturity, short life span, and many young.
- Forage species usually form dense schools, making them easy to catch.

Why do forage fish matter?

Forage fish play a crucial role in marine food webs, preying on plankton and transferring energy up to marine mammals, seabirds, and larger fish. Forage fish are also a valuable commodity in their own right, accounting for over one-third of wild marine fish caught globally. Most forage fish catch is not consumed directly as human food: 90 percent is processed into feeds for fish farms, poultry, and livestock, as well as nutritional supplements for people.

The Lenfest Forage Fish Task Force

The Task Force, a group of 13 preeminent scientists from around the world, formed to provide practical advice on the sustainable management of forage fish. It was supported by the Lenfest Ocean Program and convened by Dr. Ellen Pikitch at the Institute for Ocean Conservation Science at Stony Brook University.

Methods

The Task Force used a variety of sources and approaches to develop its recommendations, including:

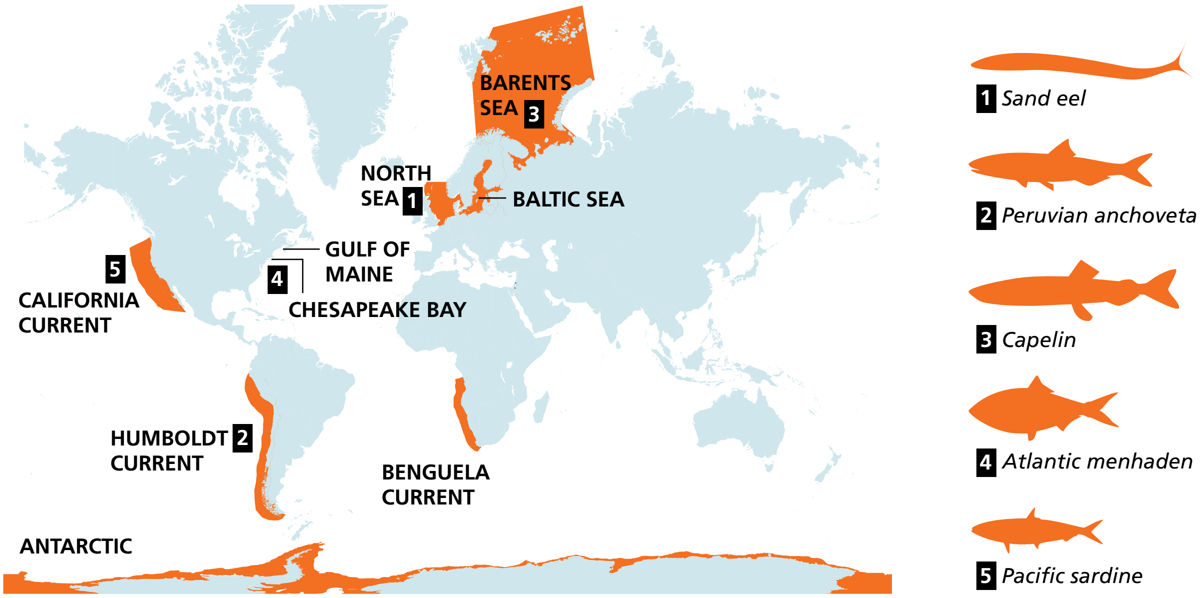
Workshops and site visits: It held four in-person meetings, where it developed its objectives, analyses, and recommendations. Two meetings—in Portland, Maine and coastal Peru—included site visits and interaction with people knowledgeable about local forage fisheries.

Review of existing theory and practice: The Task Force reviewed scientific literature, empirical information on forage fish populations and predators of forage fish, and approaches to forage fish management. (See Chapters 2 and 3 of the report for details.)

Quantitative methods: The Task Force carried out two analyses using computer models of marine food webs. First, it used 72 published Ecopath models to quantify the value of forage fish, both as a commodity and as food for other commercially fished species. Second, it used 10 Ecopath with Ecosim models to simulate the effects of various fishing strategies on forage fish and their predators. (See Chapters 5 and 6 of the report for details.)

Case studies: The Task Force report contains nine case studies. The map below shows the case study locations and some of the forage species examined. (See complete case studies in Chapter 4 of the report.)

Case study map and selected species



Main Findings

Forage fish are vulnerable

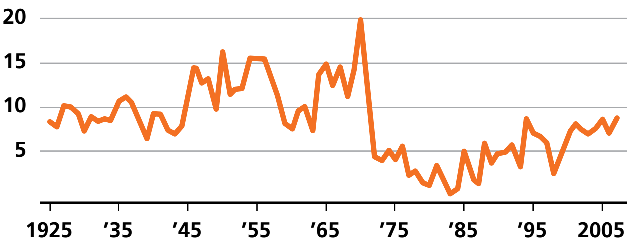
They can rebound rapidly in some cases but have biological and ecological characteristics that make them vulnerable to overfishing.

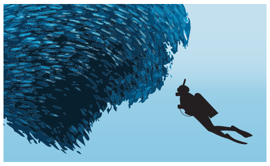
They fluctuate…

Forage fish abundance is highly variable, often unpredictable, and sensitive to changes in environmental conditions.

Peruvian anchoveta

North/Central stock, in metric tons





…and are easily caught,…

Because they form dense schools—often called "bait balls"— forage fish are easily caught, even when their abundance decreases.

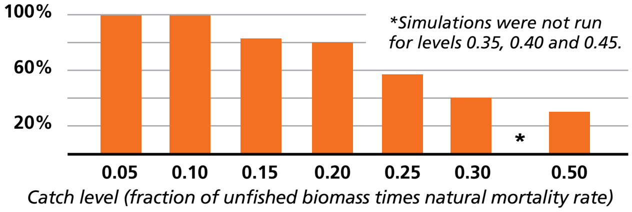
…making them vulnerable to collapse.

Fishermen might therefore be able to scoop up large numbers of forage fish during a natural population decline, greatly compounding that decline. Indeed, several forage fish populations collapsed in the 20th century, and the Task Force's analyses suggest conventional management could lead to more collapses.

Task Force analysis showed many forage species collapse, even at relatively low catch rates.

Results of the Task Force's model simulations of a strategy of constant yield (tonnage). Model tested seven catch levels on 30 species. Historically, a catch level of 1.0 was considered sustainable.

Percent of species not collapsed



Forage fish are valuable as prey

Many predators are highly dependent on forage fish…

…and decline when forage fish decline.

Modeling by the Task Force found that the more a predator's diet relies on forage fish, the more its population declines when forage fish decline.

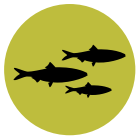
Globally, forage fish have greater monetary value as prey.

The Task Force compared the global value of the direct catch of forage fish with the value of allowing them to remain in the ocean as prey for other commercially valuable fish.

Economic importance of forage fish

TOTAL $16.9 BILLION

Direct value of commercial forage catch	Supportive value of forage fish to other commercial catch
$5.6 billion	$11.3 billion



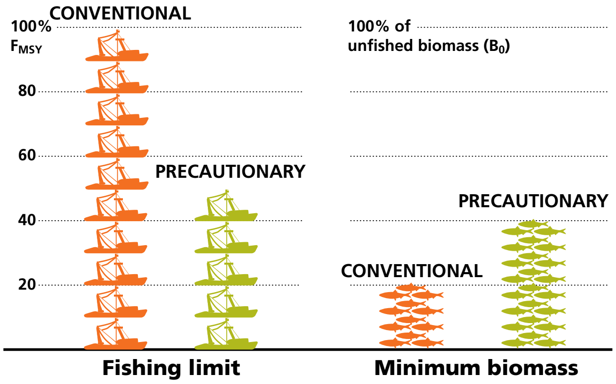
Puffin carrying sand eels for its chick, Faroe Islands, © Shutterstock

Conventional management is too risky

Task Force compared conventional and precautionary strategies…

Conventional management is based on maintaining maximum sustainable yield (MSY). The Task Force analyzed food web models to compare this strategy to several more precautionary approaches. For example, one of these methods limited fishing to 50 percent of the rate needed to reach MSY (50 percent of F_{MSY}). It also doubled the minimum biomass of forage fish that must be left in the ocean, compared to the conventional minimum. (Full results in Chapter 6 of the report.)

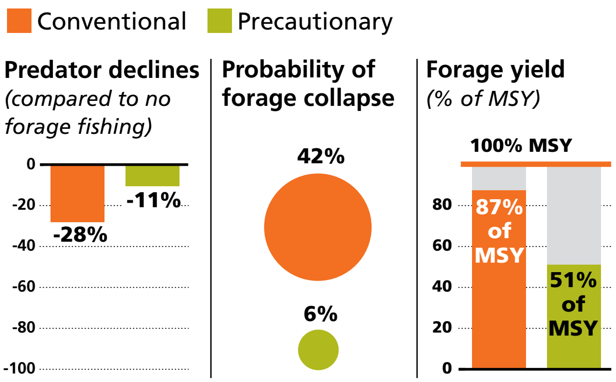
Testing a lower ceiling on forage fishing and a higher floor on forage fish biomass



…and found that only precautionary management protects predators and prey.

The Task Force found that the only fishing strategies that reliably prevented a decline in dependent predators were those that limited fishing to half the conventional rate. The figure shows that a precautionary strategy lessened declines in dependent predators and reduced the likelihood of forage fish collapses, although it also reduced the yield of forage fish.

Impacts of two management strategies



Results based on stochastic modeling by the Task Force

Recommendations

To date, scientific guidance for managing forage fisheries has mostly focused on broad principles. The Lenfest Forage Fish Task Force report makes specific recommendations that fisheries managers can use to improve the sustainability of forage fisheries.

Cut forage fishing by half in many ecosystems

According to the Task Force's food web simulations, the only fishing strategies that reliably sustain predators and forage populations are those that reduce maximum fishing mortality to half the conventional maximum. The most sustainable of these strategies also doubled the minimum biomass that should be left in the ocean to 40 percent of the unfished biomass—twice the conventional minimum.

The Task Force therefore recommends that, in most ecosystems, fishing should be half the conventional rate or less and leave at least twice as many forage fish in the ocean.

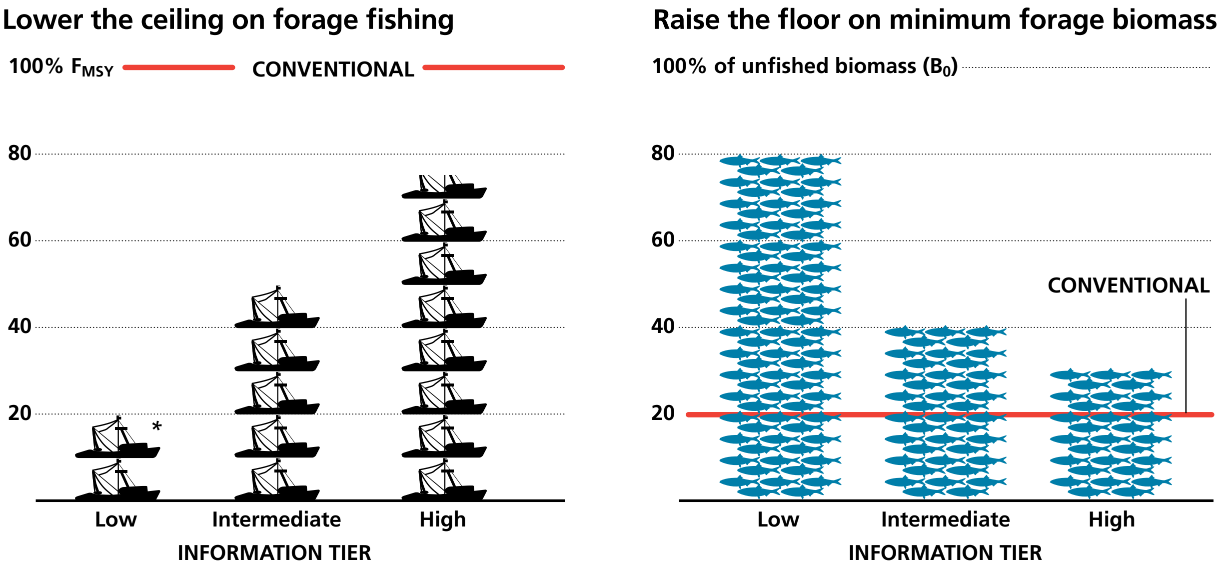
Tailor management to available information

The recommendation to cut fishing to half the conventional maximum assumes that there is sufficient information about forage fish and their interactions with predators and the environment to assess the impact of fishing. The Task Force expects that most forage fisheries now considered well-managed will fall into the "intermediate information tier."

However, managers may have very little information about certain "low information tier" fisheries. For these, the Task Force recommends fishing be severely restricted to maintain at least 80 percent of estimated unfished forage biomass in the ocean. In contrast, fisheries in the "high information tier" may be able to fish more aggressively, although they should maintain at least 30 percent of unfished biomass to account for uncertainty.

The Task Force developed a full suite of recommendations based on these tiers. The figure to the right summarizes its recommended fishing limits and minimum biomasses for these tiers, and the table on the following pages provides detailed definitions and recommendations.

Task Force recommendations tailored to information tiers.



Information tier denotes the information available to fisheries managers on forage fish and dependent predators

**Recommended F for low tier is the rate needed to achieve at least 80 percent of B_0.*

Consider spatial and temporal management

Regardless of information level, the Task Force also recommends that managers consider when and where to allow fishing. For example, it may be appropriate to close forage fisheries during spawning season or around colonies of seabirds that rely heavily on forage fish.

Focus on predators

A key foundation for many of these recommendations is the need to manage forage fish with predators in mind rather than focusing only on the target species. The Task Force recommends a “dependent predator performance criterion,” which states that managers should work to ensure that there is a greater than 95 percent chance that predators do not become vulnerable to extinction, as determined by international criteria.

A three-tiered precautionary approach to the management of forage fish developed by the Lenfest Forage Fish Task Force

(See Chapters 6 and 7 in the report for additional details)

INFORMATION TIER *Based on information needed to project fisheries impacts on forage fish and on the predators that feed on them.*	KNOWLEDGE OF . . . Forage fish stock dynamics and fisheries: *Population status, trends*	*Environmental drivers*	*Monitoring, enforcement*	+ Status, trends, dependencies of predators: *Identification of dependent predators*	*Status of predators*	*Foraging patterns*	= RECOMMENDED MANAGEMENT ACTION
LOW	Limited information on abundance, status, and trends such that there is little certainty about stock status, in particular as to whether the stock is above minimum biomass levels.	Environmental drivers have not been examined sufficiently to enable precise predictions of forage fish production dynamics.	Fishery monitoring and enforcement is not sufficient to ascertain whether catches are within specified limits.	Dependent predators have not been identified on the basis of empirical evidence from the relevant ecosystem.	Insufficient evidence to judge the status and trends of predators either known or likely to be dependent upon forage fish.	Spatial patterns of foraging are not known.	**RECOMMENDED MANAGEMENT ACTION** • No new fisheries should be allowed to operate. • Severely restrict existing forage fisheries so that depletion from fisheries is no more than 20% of unfished population (B_0). • Implement precautionary spatial closures to protect against localized depletion of forage fish, and to protect potential foraging areas of land-based predators. • Initiate data gathering to reach intermediate tier.
INTER-MEDIATE	Population abundance, status, and trends are monitored, so that catch control rules are likely to result in population levels within specified biological limits.	Putative environmental drivers of forage fish productivity are identified, providing some ability to predict production dynamics and account for them in the harvest control rule.	There is some monitoring and enforcement of fisheries so that catches are likely to be within specified limits.	Dependent predators have been identified so that effects of forage fish on their abundance can be predicted on the basis of food web models or the PREP equation.	Population status and trends of dependent predators are monitored but with considerable uncertainty.	Spatial patterns of foraging are known and sufficient to support predictions about the effects of localized depletion.	**RECOMMENDED MANAGEMENT ACTION** • Apply the "Predator Response to Exploitation of Prey" (PREP) equation, or use data or models specific to the ecosystem, to assess the impacts of forage fish depletion on dependent species (using 95% confidence interval). • Apply a "hockey stick" harvest control rule with minimum biomass (B_{LIM}) ≥ 40% B_0 and fishing (F) not to exceed 50% of the natural mortality rate or 50% of the level that achieves MSY (F_{MSY}). • Increase B_{LIM} and decrease F when the ecosystem contains highly dependent predators or when precision of diet dependencies is low. • Use spatial management to protect predators likely to be adversely affected by localized depletion.
HIGH	Population abundance, status, and trends are known sufficiently precisely and with sufficient lead time to adjust fishing levels according to a harvest control rule, resulting in a high likelihood of achieving management goals.	Environmental drivers of forage fish productivity are well known and are accounted for in the harvest control rule.	High ability to monitor and enforce fisheries regulations at-sea and/or dockside so that catches are highly likely to be within specified limits.	The functional responses of dependent predators to forage fish abundance are well defined based on empirical evidence so that effects of fishing can be determined with a high degree of certainty. Models reflect what is known from the field and are tested and modified with new information.	The population status and trends of dependent predators are measured with high certainty and at frequent intervals.	Localized forage fish requirements of dependent predators can be estimated with high precision, so that effects of localized depletion on dependent predators are well described.	**RECOMMENDED MANAGEMENT ACTION** • The harvest strategy must include an upper limit to F and a lower limit below which targeted fishing ceases (B_{LIM}), and F should be reduced as B_{LIM} approached. • The harvest strategy must include precautionary buffers that account for limits on the ability to predict fisheries and food web dynamics. • The harvest strategy must—by independent, realistic, quantitative testing—be shown to achieve the Dependent Predator Performance Criterion, protect the forage fish stock from impaired reproduction, and allow it to recover through periods of natural fluctuation in productivity. • In any case, lower biomass limits should not be less than 30% B_0, and the maximum fishing rate should not exceed 75% F_{MSY} or 75% of natural mortality. • Apply spatial management to account for localized depletion effects on spatially constrained predators.

LENFEST OCEAN PROGRAM

The Lenfest Ocean Program invests in scientific research on the environmental, economic, and social impacts of fishing, fisheries management, and aquaculture. Supported research projects result in peer-reviewed publications in leading scientific journals. The Program works with the scientists to ensure that research results are delivered effectively to decision makers and the public, who can take action based on the findings. The program was established in 2004 by the Lenfest Foundation and is managed by the Pew Charitable Trusts (www.lenfestocean.org, Twitter handle: @LenfestOcean).

INSTITUTE FOR OCEAN CONSERVATION SCIENCE

The Institute for Ocean Conservation Science (IOCS) is part of the Stony Brook University School of Marine and Atmospheric Sciences. It is dedicated to advancing ocean conservation through science. IOCS conducts world-class scientific research that increases knowledge about critical threats to oceans and their inhabitants, provides the foundation for smarter ocean policy, and establishes new frameworks for improved ocean conservation.

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