HOT TOPICS IN MARINE BIOLOGY 18.1

Is Fisheries Policy at Odds with Managing Marine Ecosystems?

For the past 50 years, marine scientists have agreed that it is crucial to use the best science to help craft a fisheries policy that would yield a sustainable fishery, where human exploitation of the sea would yield food but not collapse fish populations. But fishery science still inspires great controversy, and besides, in what other scientific field would the following statements find their way into print?

> I suggest the fisheries community . . . question whether there is not a within our own field a strong movement of faith-based acceptance of ideas, and a search for data that support these ideas. (Hilborn, 2006)
>
> Like all religious movements, the doctrine of MSY (Maximum Sustainable Yield) had effects on other doctrines. (Larkin, 1977)

In recent years, the estimates of scientists of the impact of fishing and their predictions about the future of fishing have been very controversial. It is widely agreed that certain fish stocks have been severely overfished to the point of collapse: In other words, recovery, even when fishing is relaxed, will be prolonged to nonexistent. The cod fishery of the northwest Atlantic, the Atlantic bluefin tuna, and oyster fisheries in many locations come to mind. Why the apparent irreversibility? There are at least three good reasons:

1. *The low abundance trap.* After a large population is fished to very low numbers, the remaining tiny and localized populations become extinct from varying ocean conditions as fast as they recover. At extreme low abundance, there simply are not enough young produced to counter the loss due to the dangers of predation, larval dispersal, and recruitment to appropriate habitats in the sea.
2. *Negative habitat feedbacks at low abundance.* In some cases, abundance creates a stable environment for population growth, but below a certain abundance, a negative feedback becomes prevalent. In oyster reefs, reduction of population densities below a threshold size results in the breakdown of the shell necessary for oysters to recruit to a healthy bed of shell on an oyster reef faster than shell can accumulate.
3. *Environmental change, including human changes*. As the sea deteriorates at any site owing to pollution and climate change, the smaller populations cannot produce enough young to counter changed and deteriorated environments, because small populations have a high extinction probability due to random environmental changes, and sometimes a very low probability of individuals finding mates.

These factors have led some fishery biologists to dire warnings. A well-known paper by Boris Worm and colleagues (2006) predicted a global collapse of fisheries by 2048. This **imminent collapse** (IC) **school** argues that widespread fishery collapse is rampant throughout the world, and it is a short matter of time before further exploitation will convert the ocean into a sea of jellyfish, without tuna, sharks, and other top predators. Many scientists agree that the loss of top predators has broad and negative effects on ecosystems. But there has been a recent pushback, and a **recovery-is-workable** (R) **school** of fisheries biology has emerged. Many criticized the approach of Worm et al. for faulty use of data and improper use of projections, which have a great inherent range of uncertainty. For example, the use of catch statistics, as done by Worm and colleagues, can be misleading since reductions of catch can stem from climate shifts, changed rules in fisheries, economically based shifts to other species, *as well* as true drops in fish populations due to severe overfishing.

Most fisheries biologists of the *R* school agree that many fisheries are in serious shape in some locations, but that proper controls can result in recovery, and that many fisheries are in good condition owing to good management practices. Longhurst (2007) pointed out that the UN Food and Agricultural Organization database shows stability for many fisheries in recent years. Cod stand out as a prominent example of collapse, but the cod's vulnerability may be related to its life cycle, which involves reproduction at a later age, as opposed to continual reproduction at younger age for many species of tuna (Longhurst, 1998). The *R* school has complained that the most eminent journals in the field tend to publish papers that promote the *IC* school's ideas and tend to reject replies arguing that fisheries could recover and are not in as bad shape as one might think.

So why, in such an important field that should rely on theory and proper analysis of data, is there so much controversy? Much of the problem is a matter of interpretive perspective and difference in policy objectives.

Ecosystem-based management and maximum sustainable yield (MSY) are probably the two concepts that create the most controversy. The concept of MSY is simple but the implication is quite important. Fisheries biologists believe that a considerable proportion of a fish population can be taken while still maintaining very rapid population growth. MSY is widely criticized, because it is not always clear that one can really make an accurate prediction based on the believed relationship of declining fish production as one approaches resource limitation. How many species really obey this relationship? One would expect that a strong limiting resource, such as nesting sites for egg masses, would result in a strong resource limitation that is needed to predict an MSY. But what about free spawning fish in open waters where food is plentiful? Others have criticized the difficulties of applying such a general concept when some species, such as salmon, have strong variation among stocks, making MSY estimates very difficult at sea when the stocks are intermingled.

Most important, a fisheries biologist who believes in MSY is content at accepting a fish population at 30–50%, and even lower, of the population size that would have existed without the fishing pressure. Is this sort of reduction always good? The loss of top predators should produce a trophic cascade that might cause major ecosystem reorganizations, leading to more invasive species and other undesirable changes (Estes et al., 2011). Also, it does not help that fishery management commissions have often erred on the side of higher fishing rates, which moves the fishery toward the possibility of collapse, even if MSY is the stated objective.

Although there are different interpretations of how much fishing pressure a species can stand without collapse, there is a crucial

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difference of perspective among the *IC* and *R* schools of fishery biologists. By and large, the *R* school is most concerned with the fishery take and how to manage it without collapsing the fishery. This turns around the concept of MSY, which allows for a rather severe reduction of fish stock abundance before the alarm bells of overfishing are rung. In Chapter 16 we mentioned the orange roughy, *Hoplostethus atlanticus*, a seamount fish that has been often brought to very low levels, less than 10 percent of starting stocks in many places, because modern remote sensing methods allow precise location of fish schools and deep water fishing gear. But rapid reduction of stocks can be seen as a good thing, from the *R* school perspective: "One could view the rapid decline in abundance as the fishery developed as a catastrophic collapse or, alternatively, as the planned development of a new fishery leading to near legislated outcomes" (Hillborn, 2007).

In other words, fishing down a population is just a sign of managing the fishery and attempting to find out whether the much lower level of orange roughy is just an indication of the rise of a profitable and sustainable fishery, maintained at MSY. The *IC* school might be alarmed and also argue that the severe reduction is causing cascading effects on other parts of the ecosystem, owing to strong food chain linkages. There is therefore a possible inherent conflict between managing a fishery through the prism of MSY and ecosystem-based management. Those who wish to maintain an interactive and sustainable total food web might object to the low levels allowable through a one-species-only approach taken by fisheries biologists applying MSY approaches. Thus one can see why the *IC* school is more alarmed at reductions of fish stocks: They are worried not only about numbers but also about fundamentally reorganizing the scheme of ecological interactions in the sea.

The important conclusion we reach is that there has to be an accommodation between the *IC* and *R* schools. Most important, the two schools have to meet to reconcile differential interpretation of data. The *R* school, heavily dependent on MSY thinking, has to adjust upward the healthy population sizes to be maintained in the ocean, if only to maintain stocks for their ecosystem as well as fishing value. The *IC* school has to acknowledge that fishing will continue, vigorously pursue an understanding of ecological consequences of bringing fish stocks down, especially top predators, but also understand that the *R* school has something to contribute to the successful management of sustainable fisheries. ■

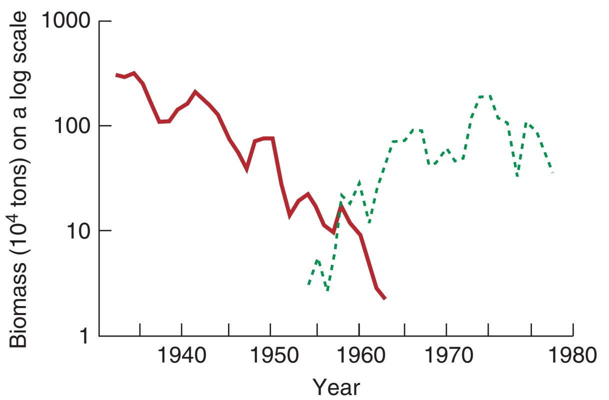

FIG. 18.13 **Increase of the anchovy (dashed curve), following the decline of the Pacific sardine (solid curve), off the coast of California.**

herring, cod, and mackerel. Fishing, climate, increased zooplanktonic food for larvae, and pollution have all been suggested as factors, but the one clear fact is the presence of strong fluctuations in population size.

Fish populations consist of many age classes that grow and reproduce simultaneously. Most species, with the exception of some like Pacific salmon, spawn more than once, usually on an annual basis. The individual factors that collectively affect each year class may have a profound effect on population size. Variation in recruitment, for example, may have a great effect on the subsequent age structure. If a given year class is extraordinarily successful, it will appear as a major peak in the size structure of the population and will contribute many more young than will other year classes. Strong fluctuation in recruitment will cause great perturbations in the age structure of subsequent years in the population. Year classes can often be traced through several years as a size peak (as was shown in **Figure 18.5**).

Random fluctuations in recruitment and mortality may be a major background variation in fish populations. It may be that such fluctuations have specific causes, but these causes may be so complex and varied that they cannot be identified individually, and their effects may be indistinguishable from random variation. Because of this potential, population biologists are often asked to estimate the degree of fluctuation of the total population and of the year-class composition, if the variation is random. Such estimation is especially important because random fluctuations alone may bring the population down to a very low level. Under such circumstances, the additional imposition of fishing mortality would be quite dangerous for the stock.

Does fishing exacerbate natural population fluctuations? One might expect this to happen, especially when fishing truncates off the larger fish, whose capacity to provide large numbers of young might compensate for failures in success of the new year classes. It was possible to measure this by the use of a long-term data set from the California Cooperative Oceanic Fisheries Investigations, which allowed the comparison of exploited and nonexploited stocks of fishes living in similar environmental conditions. Fished populations clearly were more variable than nonfished populations (Hsieh et al., 2006), which suggests that fishing can cause major instabilities that might lead to local extinctions.

■ Fish stocks characterized by long generation times, small clutches of eggs, and fewer spawnings over time are the most vulnerable to overfishing.

It is rather easy to see that some fish stocks are potentially much more vulnerable than others, owing to their life-history