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The Lead

Focusing One's Microscope

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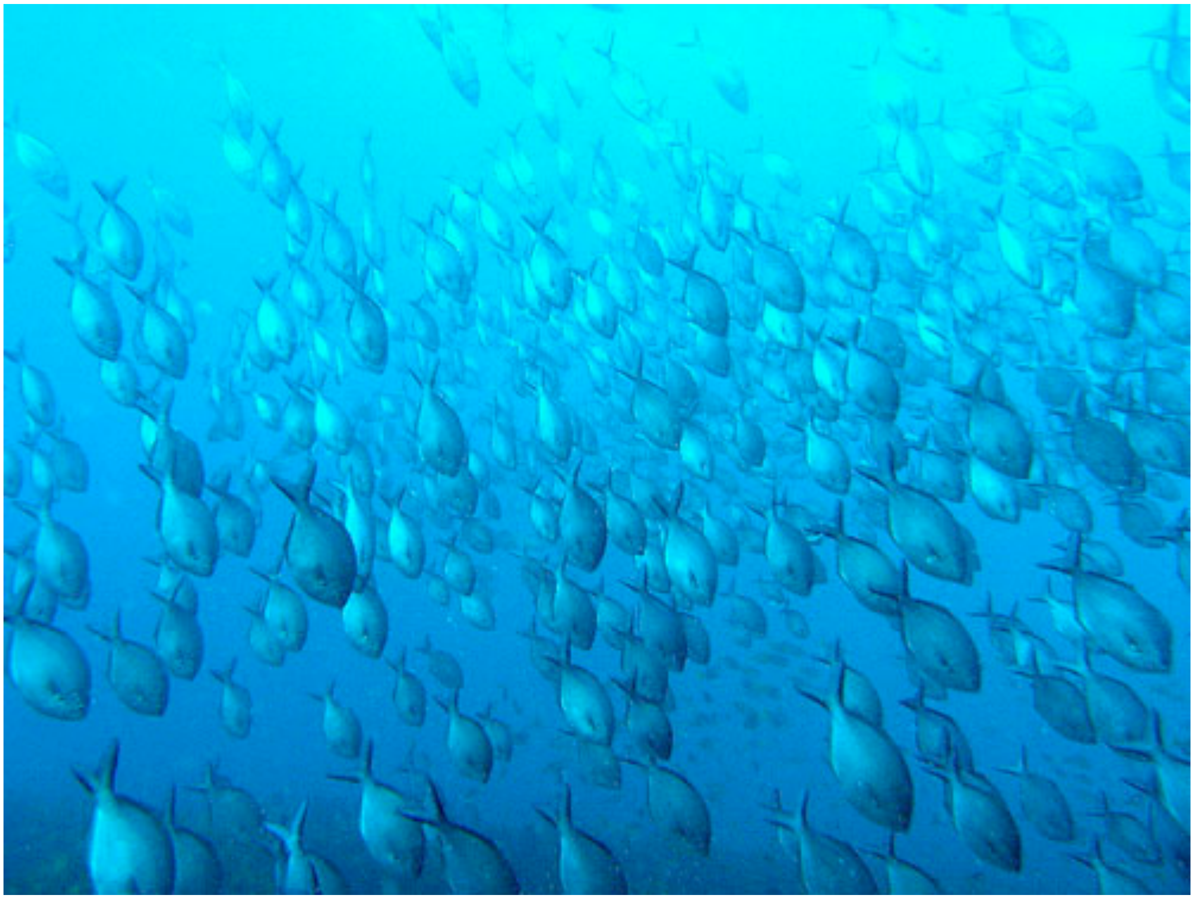

Editor's note: This essay is a response to Ray Hilborn's piece in the November 2010 issue of Chronicles *on the state of the world's fisheries. We continue to solicit other responses for publication; please send yours to rlalasz@tnc.org.*

Scientific discoveries are often a matter of focusing one's microscope — actual or virtual — and so rules have emerged on how to focus. For instance, plant and animal cells were discovered in the second half of the 17th century by Robert Hook and Anton van Leeuwenhoek, but it took over 150 years of arduous work to fully establish their role as building blocks of all living things. Kaspar Friedrich Wolff, who established that all plants were composed of cells, could be mentioned here, or Theodor Schwann, who demonstrated the same for animals.

Establishing this fundamental role of cells was complicated by the wide difference of cell sizes and other properties in various organs, and by the existence of acellular tissues in both plants and animals. But throughout these 150 or so years of sometimes bitter debate about the roles of cells, one thing was clear all along: Those who didn't believe in cells had to adjust their microscope in the manner of those who saw them, and not the other way around. Why? Because if the "cell denialists" (for want of a better term) adjusted their microscopes such that they showed only objects larger or smaller than cells, then obviously cells were not detected, as also was the case if the dye they used to highlight their tissue samples did not generate sufficient contrast, or if they were clumsy and their samples were too thin or too thick for cells to be visible.

In other words: It was easy *not* to see cells, and this is why we celebrate those who did, along with those scientists who discovered things that others couldn't see, be those things natural selection, plate tectonics or the structure of DNA.

In 1998, my co-authors and I first described the phenomenon now known as "fishing down marine food webs" mainly because we were lucky both with the data available at the time and with the setting of our conceptual "microscopes." The global catch data then at our disposal pertained to FAO's 18 large "statistical areas," and we could detect a strong fishing-down signal in about half of them. We suggested that the fishing-down process might be widespread, but we didn't have a solid explanation at that time for why it did not seem to be occurring in all areas.

"Fishing down" is essentially what happens when the fishes (and invertebrates) of a given ecosystem become vulnerable to fishing, e.g., to newly introduced trawlers. In such cases, the larger, longer-lived fishes of the top of the food web (which have high trophic levels) are depleted faster than the smaller, shorter-lived fish and invertebrates (which tend to have lower trophic levels). Thus, time series of multispecies catches *from the ecosystem and assemblage in question* will exhibit declining mean trophic levels.

Subsequent research by myself and my associates and by a number of independent authors throughout the world has helped to address the arguments of early critics of the fishing-down concept and to establish its general occurrence (see Figure 1 on the next page for an example) and intensity (about 0.05 - 0.10 TL per decade). Also, we were able to identify many of the factors that can cause the effect to be masked, thus knocking our microscope out of focus.

I have recently reviewed this work — in Chapter 3 of a book called *5 Easy Pieces: The Impact of Fisheries on Marine Ecosystems* — with reference to so-called "judo arguments," Isaac Asimov's name for points that your opponent makes that can be turned around and actually strengthen your case. For example, one judo argument against the fishing-down concept was that it originally considered shifts in between-species composition, but not within-species changes in size and hence trophic level. This particular point turns into a judo argument once

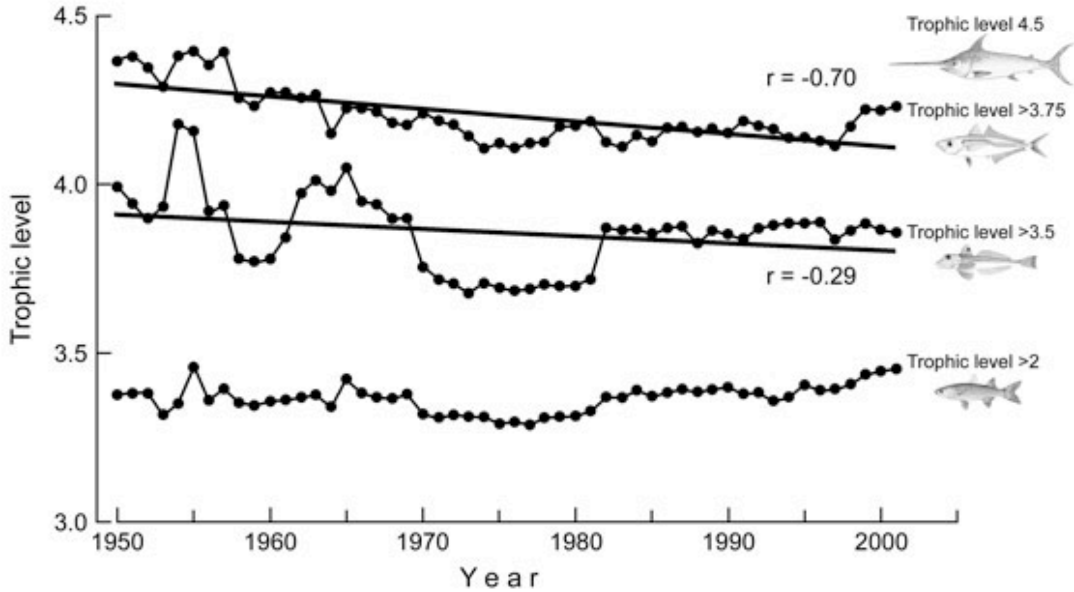

Figure 1. Fishing down in the eastern Mediterranean, as established using Greek fisheries catch statistics by K. Stergiou (In *State of the Hellenic Marine Environment* 2005). Critics of fishing down cannot explain why such patterns repeatedly emerge, so they ignore the papers that present them. This specific graph, documenting fishing down by trophic level "slices," also refutes the notion of "fishing through," which asserts that fishing down is an artifact caused by the inclusion when computing mean trophic levels of increasing catches of low-trophic-level organisms.

you consider that, when fishing intensifies, large fish (e.g., cod, grouper or tuna) become smaller and hence tend to have lower trophic levels, trends that intensify the fishing-down effect. The other judo arguments were similar, with the fishing-down denialists repeatedly ending on the mat.

Recently, *Nature* published a paper on trends in fisheries that also had its microscope out of focus, and which consequently presented a confused picture, with fishing down sometimes visible, sometimes not. It will be shown elsewhere that its authors' equally confused prose leads to many several judo arguments. Notably, they did not consider the spatial expansion of fisheries, which is one of the strongest masking effects for fishing down. Indeed, fisheries expansion, proceeding at rates ranging between 1 million and 4 million square kilometers per year from 1950 to the near present, is a masking factor that we had already identified and warned colleagues against. Thus, if you exploit a shelf ecosystem with a trawl fishery that reduces the abundance and size of the big fish and, indeed, the biomass of the entire exploited species assemblage, there is a point at which you will want to expand in deeper, offshore waters to access previously unexploited, large, high-trophic level fishes, and so on….

Consequently, if you compute time series of mean trophic levels in catches from an expanding area, chances are that you will fail to detect any fishing-down effect. This masking effect is the reason why, in science, we standardize key variables. For example, agronomists working on rice production use standardized paddies for their different treatments, and do not allow for expansion of the area planted.

Similarly, when making statements about the health of the global ocean, or the status of the world's marine fisheries, researchers must use studies that do not represent a grossly biased sample, drawn from the well-managed fisheries of a few countries or regions at the world's end, like Alaska or New Zealand, lest one's microscope be, again, out of focus. **SC**

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