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To cite this article: Arnaud Grüss (2015) Q&A: The Present and the Future of World and U.S. Fisheries—Interview with Daniel Pauly, *Fisheries*, 40:1, 37-41, DOI: [10.1080/03632415.2014.980903](https://doi.org/10.1080/03632415.2014.980903)

To link to this article: <http://dx.doi.org/10.1080/03632415.2014.980903>



Published online: 29 Jan 2015.



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# Q&A:

## The Present and the Future of World and U.S. Fisheries— Interview with Daniel Pauly

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Daniel Pauly, Ph.D. is a French researcher who became a professor at the Fisheries Centre of the University of British Columbia in 1994, of which he was the director for 5 years. He has been the principal investigator of the Sea Around Us project since 1999. He is one of the main contributors of the Ecopath modeling approach and software and of FishBase, the online encyclopedia of fish. He is also the author or coauthor of several famous papers in *Science* and *Nature* and the recipient of various awards, including the Award of Excellence of the American Fisheries Society.

**In “Toward Sustainability in World Fisheries” (Pauly et al. 2002) and “The Future for Fisheries” (Pauly et al. 2003), you expressed serious concerns about the sustainability of global fisheries and offered recommendations for rebuilding marine resources. Do you have the feeling that the situation of world fisheries is better or worse today than a decade ago?**

A journalist working for the *International New York Times* asked me the same question a few weeks ago, though with reference to my “Aquacalypse Now” article (Pauly 2009; whose cute title, incidentally, I discovered only when reading the published version). My answer to his question was an op-ed (Pauly 2014) in which I noted the tremendous progress in rebuilding stocks in the United States in the last decade and the hope that the European Union (EU) will follow suit, now that its Parliament has passed enabling legislation. However, I also noted that both the United States and the EU obtain—via direct catches or imports—over 70% of their seafood from outside of their waters, mostly from developing countries where overfishing is accelerating and that much of this seafood in fact originates from “food-deficit” countries. Thus, “we” (in the United States and EU) will have to deal with the huge equity issues that this poses and, at least, export some of the sustainability that we have recently developed.

**In “Fishing Down Marine Food Webs” (Pauly et al. 1998a), you showed that the mean trophic level (MTL) of fisheries landings has declined since the 1950s, which reflects the collapse of an increasing number of high-trophic-level fish populations and unsustainable fishing patterns. This idea was confirmed later on (e.g., Pauly and Palomares 2005). By contrast, Branch et al. (2010) found recent increases in catch, survey, and stock assessment MTL. Why are there discrepancies between your findings and those of Branch et al. (2010)? Is catch MTL increasing or decreasing in the United States, why, and what does this suggest?**

A superficial reading of the question would suggest that I led a paper claiming a widespread occurrence of “fishing down marine food webs” (FD) in 1998, that this claim was reiterated in 2005, that it is these two papers which were contested by Branch et al. (2010), and that then a debate ensued.

Actually, the 1998 paper was challenged immediately by Caddy et al. (1998); that is, by Food and Agriculture Organization (FAO) staff, who stated that they “do not disagree that a general decline in mean trophic level is likely to have occurred in many regions” but felt that it may not be solely due to FD, before proposing alternative explanations, in part based on what they said was the low quality of the FAO data. We provided what I think were satisfactory answers to this (see Pauly et al. 1998b), and the original FD paper went on to be cited over 3,200 times, as assessed by Google Scholar. The overwhelming majority of these citations, I should add, are positive or neutral; that is, not questioning the occurrence of the FD effect. In addition, Pauly et al.’s (1998a) results were replicated in numerous studies (see Stergiou and Christensen [2011] for a review). Notably, a recent study by Polovina and Woodworth-Jefcoats

(2013) analyzed the U.S. tuna fishery around Hawaii and documented a strong FD effect, which, however, can be detected only after discards are accounted for. Another recent account for FD is Molfese et al. (2014), who studied a 90-year time series from the English Channel (see [www.fishingdown.org](http://www.fishingdown.org) for more cases).

Thus, there is a huge independent body of work that Branch et al. (2010) did not consider when claiming that the FD phenomenon occurs only in a few cases, if at all. The fact is that Branch et al. (2010), as is often the case in fisheries science, did not account for the spatial expansion of fisheries, as documented worldwide in Swartz et al. (2010). Expansion is not a problem for FD when using local catch data, as most previous authors had done. However, this was not the case for the data that Branch et al. (2010) used. I should know, because what they used were FAO catch data processed by the Sea Around Us project, in which the offshore expansion of fisheries not only is not taken into account when they are “spatialized” (see Watson et al. [2004] for method) but is completely masked.

Collectively, the fisheries of a given country, when the biomass of the coastal resources they exploit declines (along with the mean trophic level of their catch), tend to expand further from the coast. As they do this, they encounter tuna, billfishes, and other large pelagic fishes with high trophic level (TL) and relatively fewer low-TL fishes. Thus, if you fail to account for expansion, you will get the impression that the downward MTL trend that was visible at first has reversed. The error made here is as elementary as that of an agronomist who would report on the growing productivity of a farm without accounting for increase in acreage planted.

This is not an idle claim. We have a paper coming out (Kleisner et al., 2014) which not only elaborates on this effect but presents an approach by which the masking effect of an expansion can be quantified, if approximately. This, and other papers to be submitted in 2015, including one with the many authors who have documented FD in their countries (with local catch data not biased by offshore expansion), and another one on worldwide biomass trends by TLs, should be able to put the notion to rest that “fishing down” is not a widespread problem. As for its prevalence in the United States, I presume that the welcome rebuilding of major stocks occurring in the country’s waters will result in an increase of MTL when estimated from biomass, and later in catches, as fishing on rebuilt stocks resumes.

**You are the principal investigator of the Sea Around Us project, which studies fisheries impacts on the world’s marine ecosystems. One of the main achievements of this project is the reconstruction of historic fisheries catch time series to improve baselines and support the development of sustainable, ecosystem-based fisheries policies. How many fisheries management bodies have used outcomes of the Sea Around Us project to improve their assessments, in the world and in the United States? Are there some success stories that you would like to share with *Fisheries*?**

Fisheries scientists have traditionally worked for the government agencies in charge of managing fisheries, either directly or indirectly via research contracts. However, there is a well-known phenomenon called “industry capture,” where the agencies tasked with regulating an industry becomes too cozy with it. This is well illustrated, for example, by the relationship between the Food and Drug Administration and the agriculture sector in the United States, and it can lead to the interest of the public in, for example, long-term stewardship of their natural endowment being compromised. This is where environmental nongovernmental organizations (NGOs) can make a huge difference. Fifty years ago, when Greenpeace helped “save the whales,” this could be done largely without scientific input—whales have more charisma than scientists. Nowadays, though, environmental NGOs cannot do without science and I see my primary role, along with that of the Sea Around Us, as supplying the NGO community with a sound scientific basis for their conservation-related activities.

The Sea Around Us likely had an indirect role—via the NGOs we work with—in pushing the EU toward recently passing a more conservation-oriented fisheries legislation, in helping the environmental NGOs in various countries to focus their campaigns on important and achievable goals, and the World Trade Organization (and the EU) in dealing seriously with the issue of subsidies to fisheries (Sumaila et al. 2013). We are also helping West African countries with understanding the real value of their marine fisheries resources and thus shaping their response to legal and illegal foreign fisheries in their waters (Belhabib et al. 2014). Thus, when Senegal recently arrested a Russian vessel poaching in its Exclusive Economic Zone, we celebrated, because one month before that we had presented to the Senegalese Minister of Fisheries with an analysis of the loss his country experiences through illegal fishing. This is all very different from doing stock assessments, but the strategic and international dimensions of fisheries policy research are also needed, and they are our niche.

Our emphasis on catch reconstruction emerged about a decade ago, when we realized that the national fisheries *landings* that the FAO receives annually from its member countries and distribute globally as the only global database of fisheries *catches* is not only problematic in a lack of precision kind of way but is also grossly biased against small-scale fisheries (i.e., artisanal, subsistence, and small-scale fisheries), because the overwhelming majority of member countries simply don’t report on them (see Zeller et al. [2007] for a study of the catches from the U.S. flag territories in the Pacific, which we carried out for the Western Pacific Regional Fisheries Management Council). The resulting zeroes in the FAO database are then interpreted as absence of catch, and the whole focus of the fisheries world is thus shifted to industrial (or “commercial”) fisheries, although these are not necessarily the ones providing most fish to most people in most countries. We are now completing bottom-up reconstructions of total catches from 1950 to 2010 for all maritime countries and island territories of the world (yes, it is lots of work!). I can’t describe the results here, which we will release in late 2014, but I am sure that they will astonish lots of folks.

**In the United States, a public law (the Magnuson–Stevens Fishery Conservation and Management Act) requires fisheries management to be based on the best scientific information available in order, *inter alia*, to achieve the optimal yield from each fishery and to promote the protection of essential fish habitats. Do you think that U.S. fisheries have been successfully rebuilt thanks to the Magnuson–Stevens Fishery Conservation and Management Act? Is fisheries management in the United States a model for the rest of the world?**

Yes, and yes. Every public lecture I do (and I do lots of them, including in the United States) emphasizes the wonders that a reasonable, well-enforced legislation can do. We need this throughout the world, notably to show that fisheries science actually works when its best results are implemented and stocks that previously had been overfished are allowed to rebuild.

**Marine protected areas (MPAs) are increasingly advocated as a primary means of rebuilding marine resources and allowing sustainable fisheries (e.g., Jones et al. 2011; Roberts 2012). Do you think that MPAs will succeed in benefiting world and U.S. fisheries? How should the global network of MPAs be designed to produce significant fisheries benefits?**

A few decades ago, when global catches were higher (yes, higher!), we were exploiting a smaller fraction of the ocean. However, in most of the world, rather than rebuilding stocks that were overexploited, fisheries expanded, and catch were maintained through expansion (Swartz et al. 2010). MPAs contribute to reversing the trend: rather than obtaining our seafood from far away, we should obtain it from our rebuilt stocks. Otherwise, our footprint (or “seafood print”?) will keep expanding even if catches do not grow, as for the impact of mining which grows even when production does not (Davidson et al. 2014). Here again, the United States took a very positive stance, with the first large no-take marine reserve in the northwestern Hawaiian Islands and the first scientifically designed network of MPAs in California. (I will get into trouble in Australia for having written this...).

**Climate change jeopardizes the ability of marine ecosystems to provide goods and services (e.g., Cheung et al. 2009, 2010b; Hollowed et al. 2013; Roberts 2013). You and your colleagues demonstrated that climate change may result in large-scale redistribution of global catch potential (Cheung et al. 2010b; Pauly 2010b). Based on your findings and results from other studies (addressing issues that you and your colleagues did not address such as ocean acidification), may U.S. fisheries (including fisheries in the U.S. Caribbean, Alaska, and Hawaii) belong to the “winners” or “losers” of climate change?**

Our first results suggested that, overall, in the next 30–50 years, the United States would not lose, or gain, from a temperature induced redistribution of catches, because losses in the subtropical areas, notably in Florida and the Caribbean, would be compensated for by gains in Alaska (Cheung et al. 2010a). However, these first analyses were rather preliminary and omitted a number of correlates of increased global temperature, notably a reduction of dissolved oxygen (Pauly 2010a), which, when taken into account, had a strong, deleterious effect on fish growth and hence productivity (Cheung et al. 2013a). Also, we once considered the effects of ocean acidification (Cheung et al. 2011) and showed that lowered pH may reduce potential catch. Thus, although the effects of lowered pH across exploited species are admittedly uncertain, we believe that there will be no “winner” from global changes, only victims. Big troubles have already begun for tropical countries, and the other countries will follow suit in a delayed fashion.

**You and your colleagues recently developed a novel index to evaluate the impacts of climate change on global fisheries, the “mean temperature of the catch” (Cheung et al. 2013b). What exactly is this index? What did it reveal? What are the implications of your findings?**

While William Cheung and I and our collaborators at Princeton developed our approach for modeling temperature-induced migration in the future, we really put the cart before the horse as we did not cover the effects that are known to have occurred in the second half of the 20th century and which, for example, were documented at the symposium of the American Fisheries Society in 1989 (Regier et al. 1990). William and I had the idea of a “mean temperature of the catch” (MTC, an obvious analogy to the mean trophic level of the catch), based on the assumption that the temperature preferendum of a fish species, which can be inferred from its average distribution, is largely fixed; that is, cannot evolve rapidly because it involves too many deep features of fish physiology (Pauly 2010a). Thus, fishes have to move when the temperature they live in is unsuitable, even if the region to which they must move is not as suitable with regards to other features; for example, food availability. Because the Sea Around Us had already plotted the distribution of all marine fish that show up in FAO’s global statistics (see [www.searoundus.org](http://www.searoundus.org)), we could compute preferenda for all of these species and do a global analysis of how fish have shifted their distribution in the last decades of the 20th century, as reflected in the MTC of the large marine ecosystems (LMEs) of the world. It turned out, for most large marine ecosystems, that the MTC increased (at a rate of 0.2°C/decade) and that it is significantly related to observed temperatures, after changes in fishing effort and large-scale oceanographic variability are accounted for. When we worked on a revision of the paper (we did five, the reviewers were tough!), we discovered that our results agree with an earlier study by Collie et al. (2008), who did a similar analysis with fishes in New England. Also, we found that ecosystems in the tropics showed a trend that is different from the rest of the ocean. MTC increased initially but then leveled off, although temperature continued to increase. This implies that species remaining in the tropics may have to either find a way to tolerate temperatures that are unprecedented in recent times or die out. This, needless to say, is bad news for tropical fisheries and countries.

**Philippe Cury (Institute of Research for Development, France) and you recently wrote a book in French about reconciling human extractive activities and natural cycles (Cury and Pauly 2013; reviewed in French by Grüss 2013). This book is outstanding and will hopefully be translated into English. In the last part of the book, you emphasize that mankind should change “operating systems.” Could you please expand on this idea for *Fisheries*? What fishing practices and management measures should primarily be promoted to ensure that world and U.S. fisheries fit a new operating system?**

This book, which we hope will soon be translated into English, makes three points in three chapters. In Chapter 1, we argue and hopefully demonstrate that, notwithstanding long-term evolutionary processes and the occasional meteors crashing onto Earth, Nature simply tends to reproduce itself, year by year, because the organisms it consists of do the same thing from one year to the next; that is, close the life cycle of which they are parts. This closing of cycles may involve long migrations, as in the case of birds, salmon, and sea turtles, or complex life cycles, as in some parasites, but, at the end, the overwhelming majority of organisms that survive and reproduce do exactly as their parent did; Nature is obstinate and moves in cycles.

In Chapter 2, in contrast, we make the point that modern humans, since their very emergence in Eastern Africa, have managed to overcome the control that predators and competitors imposed on them and to expand, through successive waves of invasion, in both population and space, to the extent that they now dominate the Earth. The expansion of industrial fisheries into the world oceans, documented in Swartz et al. (2010), is only the latest of these waves of expansion. Thus, humans, rather than being characterized by the cycles of nature, are characterized by an arrow of time, which historians call “progress,” economists call “growth,” and which definitely must be called “bad news” for the biosphere.

In Chapter 3, we thus ask what would make it possible for humans to accept, and adapt to, the cycles of Nature, rather than listing the good-intentioned but largely helpless measures that usually come at the end of books about the oceans, such as forsaking plastic bags when shopping. Thus (because we are two French intellectuals), we develop the theme that we need to graft onto the Enlightenment’s “operating system” (freedom, tolerance, democracy, etc.) a “service patch” that would automatically question the sustainability of any newly proposed enterprises we engage in, just as we now ensure that new ventures do not impinge on human rights. In the marine world, this would mean, for example, that we wouldn’t allow fisheries that modify marine habitats such as trawling.

**Changing operating systems entails major changes in our consumption of seafood. According to you, what national and global measures should be implemented to guarantee seafood security worldwide? It is likely that seafood consumption per capita will need to be reduced in developed and emerging nations. Given the limitations of livestock farming and aquaculture, to obtain and maintain a high animal protein supply per capita worldwide, should countries—including the United States—consider more seriously alternative sources of proteins such as insects?**

Satisfying, in the face of declining worldwide catches, the increasing seafood demand for developed countries while maintaining fish in the diet of millions of people in developing countries is an unsolvable problem. Aquaculture is often mentioned as a solution in this context, but what the aquaculture people in the United States and the EU usually have in mind when they talk about it as a solution is the farming of carnivorous fish, tuna, salmon, sea bass, and the like. At the risk of sounding repetitive, I must insist that this form of aquaculture cannot feed the world. In fact, the more of such aquaculture you do, the less fish you will have for human consumption because these fish are carnivores and they are fed with fish that could (and should) be used to feed people.

For aquaculture to perform as a net producer of seafood, it must be based on farming herbivores, ranging from catfish in Arkansas, fed with soybeans, to the carp and bivalves that form the bulk of aquaculture production in China.

Yes, we can eat insects since we can eat their aquatic cousins; that is, shrimp. But do we really have to? Wouldn’t it be more practical to curb our production of human protoplasm?

**To guarantee that the fishing practices and management measures described above are effectively implemented, how can top-down management be improved and bottom-up pressure on decision makers and politicians applied? Also, should scientists ensure a more comprehensive public awareness of the sustainability of marine resources to encourage people to buy or boycott seafood products wisely?**

The only way we can guarantee that governments implement existing legislation to ensure sustainability of fisheries is to make lots of noise when they don’t do what actually is their job. More people working together can make far more noise than isolated persons, which is why, in my public lectures, when asked “What should we do?” I suggest people should organize—that is, join an environmental NGO—and push for change. This I see as bottom-up activity that can make a difference, and scientists, being citizens as well, have no excuse for not being involved. In contrast, I have serious doubts that “buying and consuming wisely” can make much of a difference, although I think that we should still do it, if only because our actions should be consistent with our beliefs.

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