54. Global marine fisheries: avoiding further collapses

Philippe Cury and Daniel Pauly

SCIENTIFIC RESEARCH IS NOT ONLY ABOUT DISCOVERIES

Ernst Mayr, who had a long and a fruitful life working on evolution, wrote, from his farm in New Hampshire, a letter to the geneticist W. Provine:

In your work...please always remember that a scientist's achievement may lie in many different areas: as an innovator (new discoveries, new theories, new concepts), as a synthesizer (bringing together scattered information, sharing relationships and interactions, particularly between different disciplines, like genetics and taxonomy), as a disseminator (presenting specialized information and theory in such a way that it becomes accessible to non-specialists) as a compiler or cataloguer, as an analyst (dissecting complex issues, clarifying matters by suggesting new terminologies, etc.), and in other ways. (Cited in Provine, 2005, p. 412, Figure 2)

A scientific career is not uniform, and along their respective scientific careers the authors have worked along the lines suggested by E. Mayr (Cury, 2018, Grémillet, 2019). However, they have also involved themselves in several aspects of scientists' work not included in the letter in question, including communicating with mass media, and with various fisheries stakeholders, including non-governmental organizations (NGOs), politicians and the public at large. These stakeholders are all important, but are usually neglected when dealing with fisheries, which are often viewed the sole concerns of the fishing industry and its lobbyists. This was particularly important for both of us, as innovators, synthesizers, disseminators and communicators to address the major global challenges and transformations that the oceans are facing at an unprecedented speed and strength. Thus, we will use this account on the parlous state of fisheries globally to present some of our work – not because this work was better than our colleagues' work, but because it illustrates what one (or two in this case) could contribute in the various roles outlined above.

The approaches we used fit into three groups. The first group of approaches refers to the creation of global databases, as required to tackle issues of sustainability in the global ocean. The second group was to develop approaches that would empower our colleagues, especially in developing countries, to participate in sustainability debates, by providing them with software, models and concepts that allowed them to work even in situations where there were “no data”, as the mindless phrase goes. The third group of approaches consists of our involvement with civil society, as alluded to above. These three groups and the themes they imply are further developed below.

GLOBAL MARINE PATTERNS: THE ELEPHANT IN THE ROOM

Often, drastic ecosystem changes occurred a long time ago, but we have only anecdotes to work with (Pauly, 1995). Thus, the development of concepts for the integration of this knowledge of the past into current scientific models of fisheries has the effect of adding history to a discipline that has suffered from a lack of historical perspective, but which enriched debates about biodiversity. This requires us to identify global patterns that are shaping marine life and to move beyond ecological anecdotes, that is, to properly describe the elephant in the room, something enormous that people choose to ignore because dealing with it is uncomfortable.

Fishing is our last industrial activity exploiting a wild, renewable resource. The oceans, long perceived as an environment preserved from human action, do not seem to have escaped the general pattern of resource depletion. Here we explore a long depletion process that went unnoticed through the example of how we (still) operate when we exploit a wild, renewable resource.

Since the deployment of steam-driven trawlers around the British Isles in the 1880s, human have been able to extract from the sea far more than it could locally produce (Roberts, 2007). Thus, industrial fishing can hardly exploit a fishing ground for long; rather, new fishing grounds must be found as the previous ones are depleted (Pauly, 2019). This dynamic is well documented for the period following World War II, which saw a rapid rebuilding of the fleets in major fishing countries, particularly in Western Europe, then the Soviet Union, in East Asia (Japan, South Korea, Taiwan and later China) and a rapid expansion offshore and toward the southern hemisphere.

This expansion led to a major increase in global catch, convincing policy-makers that more boats automatically lead to more catch. In 1975, catches in the North Atlantic, where industrial fishing began to decline, but this was masked, at global levels, by the large catches of distant-water fisheries in the Global South, often in the waters of former European colonies (e.g., West Africa and South East Asia).

The net result of this continuing geographic expansion, which went along with fishing into deeper waters and targeted previously spurned fish, led, in spite of numerous local collapses (e.g., Northern cod off Eastern Canada), to the net increase of global catches until 1996, the year of global peak catches (Figure 54.1). Since 1996, the global catch extracted from the world's oceans is declining, despite a tremendous increase in fishing effort, notably in East Asia, driven by politicians who still believe in the magic that more boats is synonymous with more catch.

Note: Note the difference between the reported catch, assembled by the Food and Agriculture Organization of the United Nations (FAO) from the submission of their member countries, and the reconstructed catch, which includes all industrial, artisanal, subsistence recreational fisheries known to exist, in the waters of all countries and their overseas territories and in the high seas (see www.seaaroundus.org).

Source: Adapted from Pauly and Zeller (2016).

Figure 54.1 Trajectories of reported and reconstructed marine fisheries catches, 1950–2010

The issue that declining fisheries catches poses could be largely resolved by the introduction of stock-rebuilding programs, such as legislated and implemented in the US, in the Exclusive Economic Zones (EEZs) of maritime countries, and by drastically reducing or abolishing subsidies to fisheries that largely fund their expansion. This would help in repairing the considerable damage so far inflicted on the marine ecosystem within which fisheries are embedded. Notably, the populations of large predatory fishes (shark, tuna, cod) that regulate the functioning of marine ecosystems need to be rebuilt. The

point here is that we should be able to *reverse* present trends, characterized by fish catches consisting of smaller and smaller fish, a process known as “fishing down marine food webs” (Pauly et al., 1998; Figure 54.2), rather than aim for an ill-defined “sustainability”.

Note: When a previously pristine ecosystem becomes accessible to exploitation, it is usually the largest, longest-living fish at the top of the food chain (top left) that are affected most, because their longevity makes them more vulnerable to overfishing, whether they are sought by fishers or bycatch. In either case, the fishery then turns to medium-sized fish, often the prey of larger fish, which then benefit from an increase in abundance due to less predation. When the populations of medium-sized fish are finally depleted, the focus is then on small fish and invertebrates (shrimp, squid, etc.). Changes in the structure of the marine food web that these sequential decreases (arrow) produce, combined with the destruction of sedentary fauna by bottom trawling, lead to conditions favorable to blooms (i.e., population explosions) of harmful algae and jellyfish (see also www.fishingdown.org).

Source: Concept: Daniel Pauly; artist: Ms. Rachel “Aque” Atanacio.

Figure 54.2 Schematic representation of fishing down

By exploiting new fishing grounds, targeting new fish species in deeper waters (Morato et al., 2006), fisheries were able to hide the ever-stronger decline of their resource base. The ocean illustrates, in fact, how our inter-

actions with nature's bounty resemble a "Ponzi scheme", so named after the swindler who invented this special technique in the 1920s. His method, which promised huge, steady profits from investments, was actually unsustainable, being based on using newly acquired money to stimulate profits for the initial investors. One of the most blatant Ponzi schemes in the history of finances was that developed by the Bernie Madoff, who caused the largest losses experienced by any group of investors.

Yet, the most incredible speculative operation of all time is occurring for everyone to see – the unsustainable exploitation of our natural resources. Rather than extracting, in a sustainable manner, the interest from a capital invested in profitable ventures, we live off this capital, seemingly freed from all constraints. Like Madoff, who reached a point where he could no longer find more credulous people to fleece, the fisheries reached their peak in 1996, when fishing fleets could no longer find new fishing grounds into which to expand. Thus, catches have been decreasing since by over a million tonnes per year, demonstrating the erosion of natural capital. It is time to recapitalize marine life.

In addition to re-establishing the profitability of unsubsidized fisheries, the world must also re-establish some of the fish abundance that enables marine mammal and seabird populations to thrive. Thus, in the case of seabirds, it was shown that overexploitation of forage fish (e.g., sardine, anchovy, herring, sprat) is one of the key drivers of seabird population declines, range shifts, and extinction. The global and substantial overlap and competition between small pelagic fisheries and seabirds represents 48 percent of all marine areas, notably in the Southern Ocean, Asian shelves, Mediterranean Sea, Norwegian Sea and Californian coast (Grémillet et al., 2018). A threshold in prey (fish and krill, termed "forage fish") abundance, equivalent to one-third of the maximum prey biomass, was found below that which causes consistently reduced and more variable seabird breeding success (Cury et al., 2011). This empirically derived guiding principle embraces the ecosystem approach to management aimed at sustaining the integrity of predator–prey interactions and marine food webs. Following this simple threshold in fish population management is straightforward to implement and thus contributes to ensuring the survival of seabirds.

EMPOWERING TOOLS AND CONCEPTS

The rebuilding of fish populations can be guided by "historical marine ecology", an approach for the interpretation of historical data that followed up on the realization that "shifted baselines" are often used to assess change (Pauly, 1995). This occurs when, for example, a generation of, say, fisheries scientists, strive to evaluate the changes that have occurred in an ecosystem using only the changes that they themselves witnessed, while not considering

the changes that their predecessors witnessed. This now well-established phenomenon leads to changes being underestimated. Only by anchoring earlier states into historical data – as done in the new discipline of historical marine ecology – can this insidious underestimation of losses, and our resulting accommodation of it, be prevented (Figure 54.3).

Note: The concept of “shifting baselines” reflects the gradual loss of our benchmarks in the perception of the actual productivity of the marine world due to the progressive impoverishment of the ecosystem itself. A middle-aged fisher and even more so younger fishers, lack what older fishers – for example, in the Gulf of California (Mexico) – had, thanks to their traditional knowledge: a vision of the great wealth of fish species and their ecology.

Source: Based on an original paper by Sáenz-Arroyo et al. (2005).

Figure 54.3 The concept of “shifting baselines”

The geographic expansion alluded to above and the fact that countries or regions such as the US, Japan or the EU consume four to five times more fish than is caught in their 200-mile EEZs are reflections of a huge geopolitical imbalance, with the countries of the Global South losing out. Because this losing out also manifests itself in access to knowledge about the ecology of the fish populations exploited by both local fisheries and the distant water fleets of wealthier countries, a set of tools has been made available to researchers in developing and developed countries that now help assess fisheries also in the data-sparse regions of the world.

One of these tools is FishBase (www.fishbase.org), a freely accessible online encyclopaedia of all fishes in the world, and which contains, for most commercially exploited fish species, the essential parameters (on growth, reproduction, etc.) required for managing their populations. Another similar database, SeaLifeBase (www.sealifebase.org) does the same for invertebrates such as lobster, shrimp, clams and the like. FishBase is now known throughout the world and it has saved the fisheries departments of many countries years of work devoted to estimating parameter values that were already available, if in obscure publications.

Another tool is Ecopath, an ecosystem modelling software initially developed by NOAA in Hawaii, and which was subsequently modified for general use and disseminated throughout the world (Christensen and Pauly, 1992). Now called Ecopath with Ecosim (or EwE), this has become the only ecosystem modelling software with as many implementations in developing as in developed countries (<http://sirs.agrocampus-ouest.fr/EcoBase/>).

Finally, there is the huge database of the Sea Around Us (www.seaaroundus.org), covering fish catches from 1950 to the near present, and which provides detailed catch data and related indicators for all maritime countries of the world. These data complement the statistics sent annually to the FAO in Rome by its member countries, which are harmonized and disseminated by FAO as “official data”.

The Sea Around Us adds (1) discarded bycatch (not included in FAO statistics); (2) small-scale fisheries, not well covered by countries’ official catch statistics; and (3) estimates of illegal catches to these official catches, besides allocating them to the EEZs of maritime countries and other geographies. Due to their completeness and versatility, the Sea Around Us data are increasingly used by members of civil society, notably the staff of environmental NGOs, to evaluate policies with particular emphasis on the competition between (often distant water) industrial fleets vs artisanal and subsistence fisheries that, in many developing countries, ensure local (sea-)food security.

These tools, by providing data even for countries deemed data-poor, allow their fisheries development to be projected via scenario, our next topic.

SCENARIO BUILDING: ENVISAGING OUR COMMON FUTURE

Climate change is altering the abundance and distribution of marine species, with consequences for ocean ecosystem structure and functioning, seafood supply and conservation. Quantifying future trends based on integrated models of marine socio-ecological systems is critical to inform ongoing global assessments on climate change and biodiversity, including the Intergovernmental Panel for Climate Change (IPCC) and Intergovernmental Science-Policy

Platform on Biodiversity and Ecosystem Services (IPBES), and guide viable pathways toward achieving key policy objectives, such as the United Nations Sustainable Development Goals (SDGs) of Agenda 2030.

We both started to develop ecosystem models more than 20 years ago; at the time, it seemed unreasonable to spend time constructing such models and many colleagues thought that we were wasting our time. Still, we invested in the development, parameterization and calibration of integrated socio-ecosystem models (Pauly et al., 2003; Pauly, Christensen and Walters, 2000; Shin and Cury, 2001, 2004). Once constructed, these models helped us devise new paths towards sustainability; they also helped us not only to formulate ways to mitigate present actual and future trends, but also to identify alternative pathways.

Models are, as well, important tools to communicate as they formalize in an integrated manner the natural constraints of our actions and impacts. For the first time in our human life, scientific research has demonstrated this ability to forecast within several decades the environmental future of our oceans. Models consequently represent incredible tools for policy actions by defining limits and consequences of our actions. In a manner similar to that of Hollywood screenwriters, scientists can produce today scenarios of projected futures, this time based on past environmental knowledge and a range of predictive models. Therein, each scenario represents an outline of societal choices and synthesizes our desires and beliefs in a particular operating mode. Policy-makers thus have a tool that can thus help them to make science-based decisions in a complex and changing world.

PUBLIC AWARENESS

When policy-makers are convinced that actions are needed, they must have the public agreeing to their decision; this is why it is crucial to involve and inform the public about the present state of the environment. Another positive development is that more marine scientists (except perhaps fisheries scientists in the employ of governments) are now willing to engage with the public and share their dismay at the demolition of marine ecosystems for short-term gain. Jointly with the increasing influence of environmental NGOs with a marine focus and the growth of a cadre of knowledgeable journalists, this has led to the emergence of a public unwilling to entrust publicly owned marine resources to the exclusive use of the owners of fishing fleets.

Scientists should realize that writing articles in peer-reviewed journals is a must for their career but that policy-makers and the rest of the world will read about scientific findings only after they are translated into popularized books or other accessible media. Most often, writing books for a large audience is not considered by academics, as scientific evaluation does not take them into consideration. However, books can change our way of thinking and even our

life! Communicating results to a large audience is not simply an added value of a scientific career but a responsibility for scientists when considering urgency in a global emerging challenge.

Philippe Cury was approached in 2007 by Ronald Blunden, the French editor working for Calmann-Lévy, who told him that during his last scuba dive in the Mediterranean Sea, he saw very few fishes. He was disappointed and wanted to do something for the ocean. With a scientific journalist, Yves Miserey, *Une mer sans poissons* [A Sea Without Fish], was published within a few months in 2008, as editors are always in a rush. This book is based on scientific evidence and raised important issues related to the history of exploitation of marine resources, a first in France, which tends to systematically ignore overexploitation. The book was successful and translated into Chinese, Japanese, in even Catalan. The impact was great. Invitations by four successive French ministers, Prince Albert II of Monaco and Mr. Yohei Sasakawa, chairman of the Nippon foundation, followed, and by many institutions and policy-makers to discuss fisheries issues. Later, in 2013, we jointly wrote a book whose French title was, translated, *Eat Your Jellyfish! Reconciling the Cycles of Life and the Arrow of Time* (Cury and Pauly, 2013; Figure 54.4). This title was misleading; only the subtitle was informative, and we ended up being invited by a radio show to demonstrate how to cook jellyfish!

Daniel Pauly, besides scientific articles, likes writing essays on various oceans-related topics; one first collection of such essays (Pauly, 1994) also didn't make it to the intended public, because its initial publisher, which had promised to sell it for about \$20 was bought by a more greedy publisher, who sold it (or not) for nearly \$200. Still, he produced another collection of essays, some autographical (Pauly, 2019).

Writing such books teaches you a lot – for example, how to present scientific results to the public without distorting their meaning, and still not losing the readers. Writing books also enlarges one's audience (Cury and Pauly, 2013). Books are powerful, as they can change the world with their content. Social media have different targets and dynamics. Although YouTube and TED talks can expand one's audience, we are not fully convinced that they will survive the test of time and influence people in the long run as some books do. We believe in the magic of books. Scientists too often ignore that they have good stories, potentially of interest to laypersons – if told well. However, too few scientists are involved in communicating to the public; young scientists should communicate ecology, which is both intrinsically interesting and a matter of great urgency, given the currently and worsening biodiversity crisis.

Note: For each species of large animals studied, biologists have found a tendency for the adults to undertake large-scale breeding migrations to return where they were born, completing their life cycle. This “obstinacy” makes sense: the site in question is undoubtedly favorable to the reproduction of certain members of their species (= their parents) and, consequently, they do not need to run the risk of finding an alternative site to reproduce themselves. In Cury and Pauly (2013), this behavior is contrasted with the unidirectional arrow-like changes that we impose on nature, as illustrated by Figure 54.2.

Source: © Odile Jacob, 2013.

Figure 54.4 *Obstinate nature is a universal pattern in nature as animals always return to their parents’ breeding environment to reproduce*

CONCLUSION: DO IT NOW!

Scientific research is key to understanding our complex, connected and rapidly changing world. Most local issues can be related to global ones. Thus, scientists must make efforts to identify their elephants in the room, that is, to develop a sustainability science that can tackle global environmental objectives. Expertise to address key challenges such as climate change or loss of biodiversity is strongly needed in the marine environment. Such expertise should connect to policy-makers and the public at large to empower citizens. UN initiatives such as the IPCC and IPBES have been able to merge a huge multidisciplinary expertise around the issues of global warming and biodiversity losses, respectively, and synthesize knowledge and information into a comprehensive framework for policy-makers. This was made possible by addressing scientific questions relevant to society and developing large databases and ecosystem models to capture the dynamics of the different components – for example, marine ecosystems.

Overfishing appears to be easier to fix than mitigating the effect of climate change. What we lack, however, is a clear vision of the fisheries we want for the future (see, e.g., Pauly et al., 2003; Cury and Pauly, 2013, Zeller and Pauly, 2019). Such vision is required to define ecological but also socially acceptable solutions. For example, in our opinion, a transition is required towards small-scale sustainable fisheries that are selective, protect biodiversity, are energy efficient and create jobs (Pauly, 2018). It is time to make fisheries really sustainable and to stop trusting that Ponzi will find a way.

What we both learnt from those many years of research is “Do it now!” Chance is that if you do not do what you think could change things around, nobody else will do it.

REFERENCES

- Christensen, V. and Pauly, D. (1992). ECOPATH II: a software for balancing steady-state ecosystem models and calculating network characteristics. *Ecological Modelling*, **61**, 169–85.
- Cury, P. (2018). Obstinate nature. *ICES Journal of Marine Science*, **76** (2), 384–91.
- Cury, P., I.L. Boyd and S. Bonhommeau et al. (2011). Global seabird responses to forage fish depletion – one-third for the birds. *Science*, **334**, 1703–6.
- Cury, P. and Y. Miserey (2008). *Une mer sans poissons* [A Sea Without Fish]. Paris: Calmann-Lévy.
- Cury, P. and D. Pauly (2013). *Mange tes méduses! Réconcilier les cycles de la vie et la flèche du temps* [Eat Your Jellyfish! Reconciling the Cycles of Life and the Arrow of Time]. Paris: Odile Jacob.
- Grémillet, D. (2019). *Daniel Pauly, un océan de combats* [Daniel Pauly, An Ocean of Struggles]. Marseille: Éditions Wildproject.

- Grémillet, D., A. Ponchon and M. Paleczny et al. (2018). Persisting worldwide seabird–fishery competition despite seabird community decline. *Current Biology*, **28**(24), 4009–13.
- Morato, T., R. Watson, T.J. Pitcher and D. Pauly (2006). Fishing down the deep. *Fish and Fisheries*, **7** (1), 24–34.
- Pauly, D. (1994). *On the Sex of Fish and the Gender of Scientists: Essays in Fisheries Science*. London, Chapman & Hall.
- Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology & Evolution*, **10** (10), 430.
- Pauly, D. (2018). A vision for marine fisheries in a global blue economy. *Marine Policy*, **87**, 371–4.
- Pauly, D. (2019). *Vanishing Fish: Shifting Baseline and the Future of Global Fisheries*. Vancouver: Greystone Books.
- Pauly, D., J. Alder and E. Bennett (2003). The future for fisheries. *Science*, **302**, 1359–61.
- Pauly, D., V. Christensen and J. Dalsgaard et al. (1998). Fishing down marine food webs. *Science*, **279**, 860–63.
- Pauly, D., V. Christensen and C.J. Walters (2000). Ecopath, Ecosim and Ecospace as tools for evaluating ecosystem impact of fisheries. *ICES Journal of Marine Science*, **57**, 697–706.
- Pauly, D. and D. Zeller (2016). Toward a comprehensive estimate of global marine fisheries catches. In D. Pauly and D. Zeller (eds), *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Washington, DC: Island Press, pp. 171–81.
- Provine, W.B. (2005). Ernst Mayr, a retrospective. *Trends in Ecology & Evolution*, **20**, 411–13.
- Roberts, C. (2007). *The Unnatural History of the Sea*. Washington, DC: Island Press.
- Sáenz-Arroyo, A., C. Roberts and J. Torre et al. (2005). Rapidly shifting environmental baselines among fishers of the Gulf of California. *Proceedings of the Royal Society B: Biological Sciences*, **272** (1575), 1957–62.
- Shin, Y.-J. and P. Cury (2001). Exploring fish community dynamics through size-dependent trophic interactions using a spatialized individual-based model. *Aquatic Living Resources*, **14**, 65–80.
- Shin, Y.-J. and P. Cury (2004). Using an individual-based model of fish assemblages to study the response of size spectra to changes in fishing. *Canadian Journal of Fisheries and Aquatic Science*, **61**, 414–31.
- Zeller, D. and D. Pauly (2019). Viewpoint: back to the future for fisheries, where will we choose to go? *Global Sustainability*, **2** (e11), 1–8.