A Life by the Sea

An empathetic biography of Daniel Pauly tells the story of a scientist committed to the study and protection of the oceans

Daniel Pauly and I met on the second day of my marine studies in Kiel, back in late 1969 and we've been friends ever since. Little did I know then about his dramatic, novelistic life up to that point: He had been 'kidnapped' by a Swiss family from his single working mother in Paris after the Second World War and later kept by them as a *domestique* (servant). Some of the details I only discovered when reading David Grémillet's brilliant new book on Daniel's life, translated from French to English by Georgia Lyon Froman.

At the age of 17, Daniel came to Germany to earn a living as a worker. He managed to weather the hardship of four years of evening school, until he achieved the diploma that opened the doors to his extraordinary academic career. Then, at the age of 19, he found his mother, along with her husband and his five siblings, in France. He was in high school when the French army discovered his whereabouts in Germany and wanted to draft him, but then decided he was no good for the army. Two more years of work and study followed. By the end of 1969 he had just come back from his first trip to the United States in search of his biological father, a black American soldier. During his travels in the US, he had discovered what it meant to be black, something he had not experienced in the same way during his upbringing in Europe.

His friendliness and 'big mouth' impressed me very much during my own first venturing far from home, trying to find my feet in the new experience of university studies. The city of Kiel was once a naval base with shipyards and brick buildings characteristic of Wilhelmenian times. Later on, not everybody would see Daniel in a particularly friendly light because he did not shy away from controversy. But I guess most people who knew him then will agree on the 'big mouth' label and his penchant for 'big ideas'.

It was the time of student protests and we got our share in Kiel as well. Daniel stood out from the rest of us—not only because he was older but also because he was very articulate, had a lot more reading under his belt, and did not suffer fools gladly. He was the glue binding an entire group of socially minded marine biologists; he always went the extra mile to connect, support and stimulate. Readers will find an echo of this attitude in Grémillet's insightful narration of the later stages in his life, in how he steadfastly supported students and peers, particularly from the Global South. The book is indeed more than a mere biography with a towering character at the centre. Grémillet weaves snapshots of the lives of an entire generation of marine scientists into the story, drawing from his wide-ranging research and interviews.

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A lion's share of the narration is devoted to Pauly's extraordinarily productive scientific endeavours (profoundly inspired by Darwin) and his quest to uncover the natural laws and mechanisms that produced

This article is by ***Cornelia E Nauen*** *(ce.nauen@mundusmaris.org), President of Mundus Maris—Sciences and Arts for Sustainability*

ROGER PULLIN

Pauly in Anilao, the Philippines, in 1986. "All I see down there is conflict, fish spending their time chasing each other and fighting—I'm swimming through the tragedies of the deep," he said.

the geological formations, plants and animals he observed. Darwin's characteristic willingness to learn from all the people he encountered during his studies and on the voyage of the 'Beagle' enabled this superb natural scientist to formulate a theory that encompasses all of humanity, embedding us within the same natural world.

Sent to Indonesia in 1975 to develop a trawl fishery, under contract with the German Agency for Technical Cooperation (GTZ, at the time), Daniel encountered tropical biodiversity. During a week-long exploratory survey on the *Mutiara 4* research trawler, a typical one-hour haul "would yield 200 kg of fish, and there were 150 different species, of which only 80 were known". This convinced him that the assessment methods developed in the North for targeting one or two dominant species simply wouldn't work. The data required were the identity of the fish, their age, weight at age, abundance and an estimate of natural mortality.

Natural mortality is not provoked by fishing but by predation and other natural processes. Or, to put it differently, managers required detailed information on growth, mortality and the recruitment schedules of fish into the fishery, that is, the time and size when young fish become vulnerable to the fishery. Age was typically determined by reading annual rings in broken-up otoliths examined under the microscope, an "extremely meticulous technique". Otoliths are calcium structures in the inner ear of vertebrates, including us humans, which provide a sense of balance. In the tropics, the seasonality is less pronounced than in cold and temperate waters, so such a time-consuming method for age determination was utterly impossible.

How to find an alternative? In his energetic search for an answer, Daniel developed what became his unique approach throughout his academic life—a systematic search in the scientific and grey literature, up and

down the accessible libraries, for all the information he could find. He was on the hunt for the basic principles of growth and mortality, which would apply to ALL fish. This was spurred by his discovery of the Hungarian theoretician von Bertalanffy's generic growth formula and, building on his research, Beverton and Holt's influential work on the dynamics of exploited fish populations.

In the process, he collected any publication containing fish size at age data and estimates of natural mortality within reach. In those times, without the Internet and portable computers, he developed a card collection, one per fish species, gathering information about 515 species from 978 distinct populations, including 100 estimates of natural mortality. This is why he resented the much-used declaration: "Nothing is known about XYZ, therefore we need an expensive survey." From then on, he also preferred extensive literature research to lengthy field work.

Growth curves

Analyzing the data with the help of a colleague in the physical oceanography department, he saw the known pattern of faster growth of fish in tropical temperatures, and found a strong correlation between their natural mortality, growth rate, maximum size and the average temperature in their distribution range. The publication of his equation and the complete data set for 175 fish species made a big splash. It set the tone for his later work. He went to great lengths in offering open access to the theory and data, to enable others to move the entire field forward, especially in the Global South, where there were fewer opportunities for scientists and library facilities were limited.

Daniel's PhD thesis established the fundamental relationship of gill size and water temperature in limiting fish growth, thus generalizing von Bertalanffy's growth formula. In hindsight, with a lot of additional evidence analyzed and published since, he laid the foundation for understanding why fish spawn and why their growth slows down, besides a host of other phenomena. Through this and other work, Daniel was discovering the fundamental mechanism governing the growth of all fish and, more generally, all water-breathing organisms. These explanations can, and should, be used for fisheries management, informing stock recovery and conservation efforts. Such science has the power to help understand not only the specific cases, but to formulate hypotheses and expectations for many unstudied cases and other life cycle parameters.

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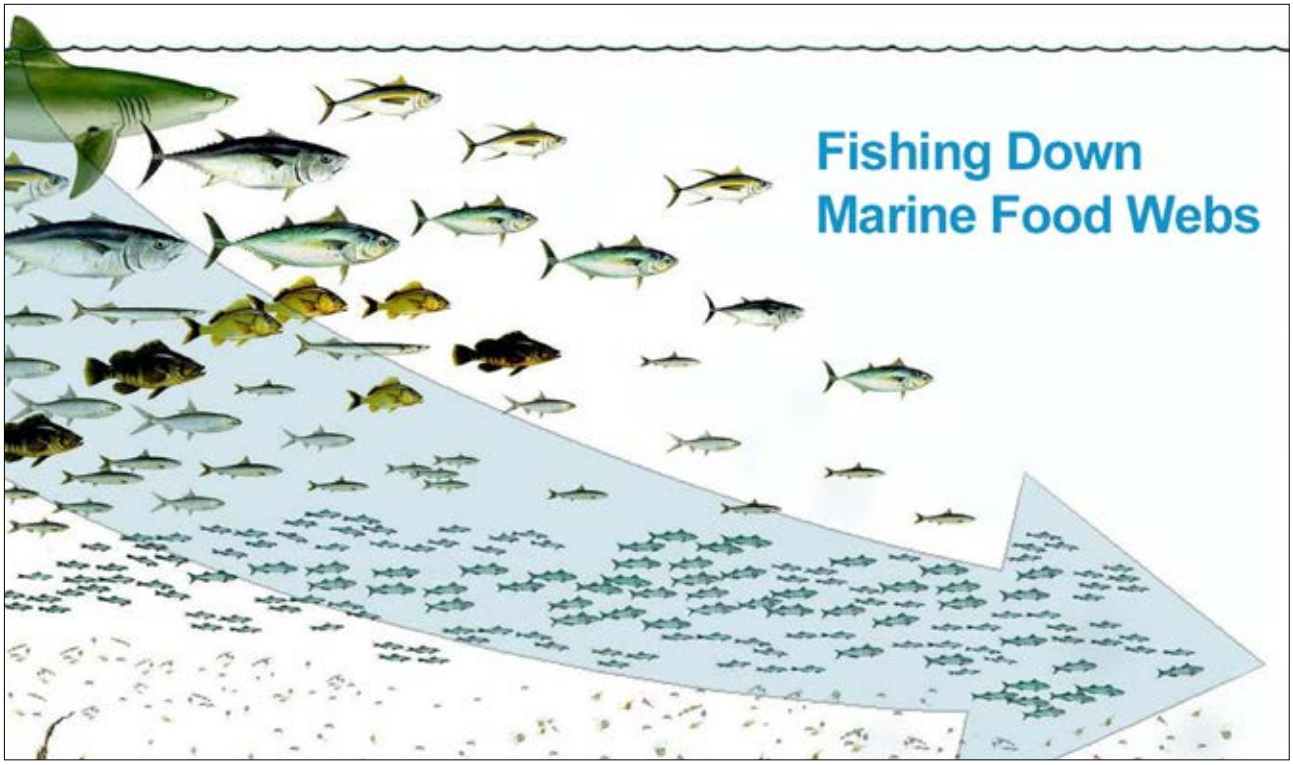
Grémillet chronologically traces Daniel's career with the International Center for Living Aquatic Resources Management (ICLARM) in the Philippines, where he became the scientific co-manager of the San Miguel Bay project. It opened up a fantastic opportunity for combining ecological work with research into the social dimension of fisheries. Based on the idea of two local students, this multi-dimensional study of the bay fisheries in the Bicol Region, some 200 km southeast of Manila, is probably unsurpassed in its wealth of detail. The evidence-based recommendations included advice to help diversify social and economic activities to make for more robust livelihoods within fisheries and beyond, particularly in a growing population. However, despite the rigour, the message was not taken seriously by those in charge of setting the rules and enforcing them.

It was also the time when Daniel and his colleagues revived and modernized a method of fitting growth curves to chronological size-frequency distributions of fish, first developed at the end of the 19th century by C.G. Johannes Petersen, a Danish marine biologist. The successive versions of the Electronic Length Frequency Analysis (ELEFAN), improved by Daniel's

RACHEL ATANACIO



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Filipino assistant Maria Lourdes (Deng) Palomares at ICLARM, became a great hit.

And not only in tropical countries where age determination of fish with otoliths was problematic! She remained at his side when he moved to Vancouver, Canada, eventually growing into the role of the scientific project manager of the 'Sea Around Us'.

During the time at ICLARM, Daniel forged a number of lasting friendships and collaborations with the likes of Jay Maclean from Australia and Rainer Froese from Germany. The former was a gifted wordsmith, editing countless scientific reports and writing prose for children and adults as well. The latter turned Daniel's fish card collection into a database: FishBase. It is the most comprehensive public information system of all fish species known to science. In the early 1990s, the European Commission (EC) first financed an initial consolidation of the database, as a sort of proof of principle—it could be done on personal computers that had begun to appear.

Once this was done and more content became available, the EC accepted the request of African, Caribbean and Pacific (ACP) countries for a major development and training programme. Modern fisheries analysis methods and published data would be made available to their understaffed administrations and environmental NGOs. At the time, I was working in the Cooperation Department and I was happy to facilitate the unanimous agreement of EU Member State representatives to fund this programme.

Towards the end of the project, publishing on the Internet was gradually replacing floppy discs, CDs and DVDs that had to be tediously dispatched to hundreds of users in countries around the globe. The creation of a multi-agency FishBase Consortium laid the foundation for the continued development of FishBase beyond the initial project funding. A dedicated team of encoders in the Philippines is the backbone of data entry and is still beavering away at extracting, standardizing and inputting

information on fish biology, inspired and supervised by Daniel, Rainer and Deng.

FishBase now covers 34,700 species, 324,200 common names in more than 300 languages, 61,000 pictures, and information extracted from 58,400 references. It enjoys the support of 2,440 collaborators around the globe. Large numbers of people consult it; it has one million visits per month.

Daniel moved to the University of British Columbia (UBC) in Vancouver in 1994, but he kept his ties to ICLARM. Together with Villy Christensen, a Danish fisheries biologist hailing from a fishing family, he developed a mass-balance ecosystem approach based on earlier efforts of a US colleague, Jeff Polovina. Ecopath—later joined by Ecosim and Ecospace—pulls together many studies, often by specialists of one type of organism. The idea is that the flows of biomass and energy within an ecosystem have to balance out in nature. Put simply, you cannot have large numbers of top predators without sufficient primary production and prey species.

Marine algae, primary producers using the Sun's energy to build up organic matter through photosynthesis, account for about half the oxygen in the atmosphere. They are assigned Level 1. Small crustaceans like copepods and other tiny animals (zooplankton) feeding on plants are included in Level 2. Fish like sardines, anchovies and herring that feed on the phytoplankton and zooplankton are between Levels 2 and 3. A rough-and-tumble transfer rate from one trophic level to the next is 10 per cent, while about 90 per cent of their energy is needed for maintenance of their bodies and growth. That means one million tonnes of primary producers support about 100,000 tonnes of zooplankton, 10,000 tonnes of secondary consumers, but only 100 tonnes of top predators in Level 4, like some of the tunas, big cod or oceanic sharks. It is, therefore, not surprising that some of the biggest marine animals, including the largest mammals and the whale shark (*rhincodon typus*, the largest living fish), are feeding low in the food web by filtering plankton or eating other small invertebrates and small fish.

Here, Grémillet takes the reader through Daniel's nascent working hypothesis, which triggered yet another major search through literature to understand the various species within their ecosystem, developing a broad classification of such ecosystems. These can then be assessed for their efficiency of channelling energy in the system to the species humans like to consume. Alternatively, heavy fishing may have disrupted the food web at the top and middle layers, directing more energy into jellyfish, bacteria and other non-resource species.

In a landmark paper based on the analysis of country-wise catches, published by the Food and Agriculture Organization of the United Nations (FAO), Daniel called this effect "fishing down the food web". The emblematic picture, by artist Rachel Atanacio in the FishBase team, has been used over and over, appearing in several incarnations. The trend is stronger in those parts of the ocean that have been industrially fished for a long time, like the North Atlantic. It is sometimes masked by fisheries moving on further south from overfished regions and also fishing deeper down. Thus, in the expansion phase of these fisheries, using ever more powerful and more sophisticated gear and fish location equipment, it could appear as if the index was moving up the food web. But these effects were only short-lived and usually not the result of improved management, because the range and reach of industrial fisheries now extended to all parts of the ocean. But, as described in this biography, distinguishing the driving forces again required a massive effort in hypothesis-driven data collection and analysis, which did not advance without controversy.

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These gradual changes in ecosystems are not easily discerned even by researchers and managers. Every generation of professionals tends to take the state of the environment at the beginning of their career as their reference point. This way, long-term changes largely go unnoticed, a widespread phenomenon Pauly characterized as "shifting baseline syndrome", a concept that has been widely taken up. Shifting baseline syndrome is indeed the reason why it can be problematic to refer to sustainable fisheries as an objective today, when we should collectively set our eyes on rebuilding and recovering marine ecosystems so as to restore at least the major part of their earlier size, composition and productivity.

The research in other branches of the food system, notably at the International Rice Research Institute (IRRI) in Los Banos, where ICLARM was based, took a global perspective in the light of the challenges of feeding a growing human population. That inspired Daniel to try something comparable for fisheries. The occasion arose when the Pew Charitable Trusts accepted his idea of building a global information system on the fisheries impact on the ocean and providing management advice.

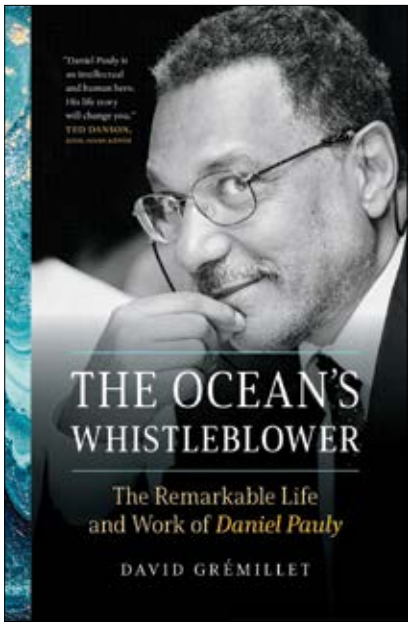
Based at the UBC Fisheries Centre in Vancouver, the starting point was again the global FAO statistics of nominal catches by country. The core team around Dirk Zeller, Reg Watson and Deng Palomares, among others, together with a large network of collaborators in each and every country, dug up a lot of additional information about extraction from the ocean. A good deal of this data was not reflected in the countries' official transmission to the FAO. But, as Daniel used to say, "fishing is a social activity; it casts its shadow and leaves many traces."

The combined efforts helped to derive more realistic estimates of effective catches, whether they concerned the often poorly recorded artisanal, subsistence and recreational fisheries or the discards at sea, and even illegal, unreported and unregulated (IUU) fishing. The 'Sea Around Us' initiative was born, named in honour of Rachel Carson, the author of the prize-winning book by the same title, and a role model of ocean study and protection. Sea Around Us constitutes a gigantic push to put detailed data and estimates (searchable by various criteria) at the disposal of anybody who cares to look.

The discrepancies between official records and what happens on the water can be huge, particularly in countries with under-resourced statistical systems, weak governance and poor law enforcement. The results showed that the reported peak global landings clicked in at 86 mn tonnes, while the real catches were likely to be 130 mn tonnes, 53 per cent higher than officially recorded, and falling since 1996. The study revealed the impacts of bad investments and management decisions, resting on a severe underestimation of the risks of overfishing.

Marine ecosystems are in much poorer state than even many specialists discern. The temperature increase in the upper layers of the ocean due to climate change is exacerbating that sorry state of affairs. What the reader of this review may have expected by now, and what Daniel published together with William Cheung, is that fish move polewards to remain within their preferred temperature range. And that they will shrink in size, something observable already.

This biography is also testimony to an exceptionally large number of training courses and capacity-enhancing activities Daniel invested time and energy into, including supervising droves of MSc and PhD students. That enabled him to build the large and lasting collaborations so important for his ambitious initiatives to drive the development of science-based principles underpinning our understanding of the ocean, its ecosystems and fisheries. Striving for the acceptance of what he calls GOLT or the Gill-Oxygen Limitation Theory, is what is driving Daniel in this last phase of a remarkable scientific career. He banks on its explanatory power for many trends we see in fisheries and



aquaculture. In his trademark style, he is marshalling new evidence to underpin it.

Prolific and influential

Reading David Grémillet's well-researched biography, written with empathy and understanding for the scientific and social processes he covers, the reader will dive deeper into the life and work of this prolific and influential scientist. There are descriptions of many companions and some adversaries. The book will not leave the reader indifferent. Georgia Lyon Froman's translation does not read like one, but exemplifies what Umberto Eco called a negotiation process between two languages and their cultural spheres. With a couple of exceptions, she captures the right terms to transport the superb French original into a native Anglo-Saxon environment. I hope that it inspires many others to follow in her footsteps and weigh up short-term interests against solid scientific evidence. That may help us all to become wiser in our investment and management decisions.

It should also promote the spread of the trust and co-operation we so desperately need to get out of this global crisis of our oceans. The crisis puts the weakest members of our societies, who rely the most on a healthy ocean, at an additional disadvantage, something Daniel Pauly has seen in practice and commented on extensively in his writing and lecture. Restoring marine ecosystems would allow us to stem the current wastage of a few and harvest for the many. The NGO community working on social and environmental issues in fisheries and the oceans can find a huge amount of material to support their causes. This community has a special responsibility to use the science as effectively as possible, given that many citizens now trust NGOs more than governments.

The Ocean's Whistleblower: The Remarkable Life and Work of Daniel Pauly by David Grémillet, translated from French by Georgia Lyon Froman. David Suzuki Institute and Greystone Books, Vancouver/Berkeley, US. pp 349.

For more

FishBase
www.fishbase.de / www.fishbase.ca / www.fishbase.org

Sea Around Us
https://www.seaaroundus.org/

Anecdotes and the shifting baseline syndrome of fisheries
https://www.sciencedirect.com/science/article/abs/pii/S0169534700891715?via%3Dihub

Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining
https://www.nature.com/articles/ncomms10244