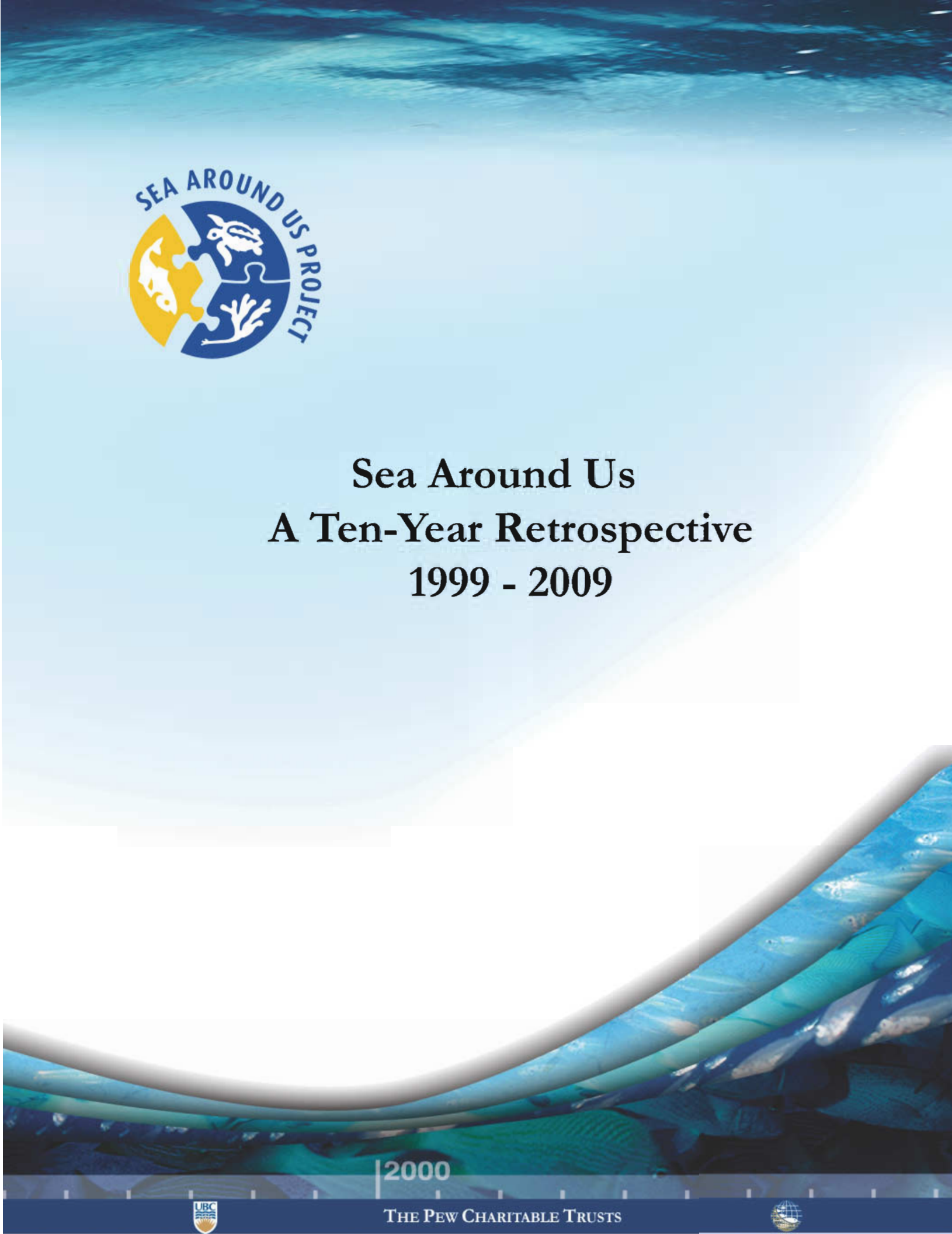
Sea Around Us
A Ten-Year Retrospective
1999 - 2009



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Sea Around Us: A Ten-Year Retrospective, 1999 - 2009

Sea Around Us, A Ten-Year Retrospective, 1999 - 2009
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SEA AROUND US, A Ten-Year Retrospective, 1999 – 2009

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FOREWORD

Over-exploitation of the world's fisheries is now widely recognized, but until relatively recently the oceans were commonly regarded as containing an almost inexhaustible source of fish and other life. Although a series of events, such as the collapse of Atlantic cod stocks in Newfoundland in 1992, awakened people to the fact that even once abundant fisheries like cod could be decimated by overfishing, researchers at the *Sea Around Us* have been instrumental in developing a comprehensive and coherent picture of what is really happening globally to marine life. Since the project's inception in 1999, these scientists have illuminated the human footprint on the oceans, building an immense global database that for the first time permits researchers to truly elucidate changes in ocean fisheries and their impact on the world's ecosystems.

A collaboration between the Pew Environment Group and the University of British Columbia, the *Sea Around Us* project is now celebrating its tenth anniversary. The project has not only greatly enriched the scientific understanding of what is happening to fisheries worldwide, it has also provided a rich array of data that has and will continue to facilitate the development of policies and practices that will help decision makers and resource management agencies do a better job of protecting living marine resources.

Since early 2005, when the *Sea Around Us* published a five year retrospective of its work, the project has contributed increasingly sophisticated analyses of trends in global fisheries that allow policy-makers and fisheries managers to make more accurate and informed decisions. For example, the project developed methods for reconstructing catch statistics from coastal countries, adding unreported catch to official reports of fisheries landings, and illuminating the importance of small scale fisheries, thereby providing a far more comprehensive portrait of global fish catch than had ever been made available previously. The project has also published highly credible research results intended to inform particular global marine policies where science is a question. Clear scientific findings from *Sea Around Us* researchers and colleagues demonstrated the inaccuracies of an argument being made by some nations that the International Whaling Commission should allow whaling to resume because whales consume excessive quantities of fish that would otherwise recover from over-exploitation and be available for human consumption if there were fewer whales.

There is a significant need for scientific research that enhances our understanding of how marine ecosystems function and of the impact which human activity is having on these systems. This work is not only important for scientific reasons. It is of critical importance to guiding and informing the way that this and future generations of people manage their relationship with the sea. The *Sea Around Us* project was inspired by the vision of making science more relevant to fisheries management and of improving the quality of that management by providing a knowledge base upon which to base decisions rather than having them driven by the vagaries of politics and the pressure of special interests. Over the past ten years, this project has made an immeasurable contribution to injecting sound science into the fisheries debate. While we still have a ways to go before science occupies its rightful place at the management table, we are a lot farther down that road today than we have been in the past, and much of that progress is due to the voluminous body of work produced by the *Sea Around Us* project, work that will continue to pay dividends for years to come.

JOSHUA REICHERT, Ph.D.
Managing Director
Pew Environment Group
Washington, D.C.

PREFACE

It is my pleasure to introduce this retrospective on ten years of accomplishments by the *Sea Around Us*, a collaboration between The University of British Columbia in Vancouver, Canada, and the Pew Environment Group, Washington, D.C., USA, devoted to assessing the impact of fisheries on the world's marine ecosystems, and proposing policies to mitigate these impacts.

The project started in mid 1999, and thus celebrated its tenth anniversary in July 2009. In early 2005, we issued a five-year retrospective, which emphasized the wide scope of our work, and our productivity. This retrospective is similar, except that our scope has become even wider, with more emphasis on fisheries economics and public policy, and our productivity has increased more than threefold – at least as measured by the number of peer-reviewed contributions authored or co-authored by our members. The reason for this massive increase is obvious: it took us several years to create the complex of global databases that allow inferences on the global ocean. Now that this complex is in place, it has become more straightforward to detect regional or global trends that were previously not visible, to assess them, and to develop policies to deal with them.

Thus for example, we can now deal with global catches not only in terms of the 'official' global landings assembled and disseminated by the Food and Agriculture Organization of the United Nations, but in terms of their Illegal Unreported and Unregulated (IUU) components, which adds to the global catch, and with the fishing effort, the gears and the costs (including subsidies) required to generate that catch, along with its economic value and its disposition through international trade. In addition, we can infer long-term trends, because most of our databases start in 1950, and thus span over half a century. Moreover, in some cases where the science allows this, we project these trends into the future, as we are now beginning to do in our studies of global change impacts on biodiversity and fisheries potentials.

The availability of the *Sea Around Us* databases not only allows for more, deeper work by project members, including a host of productive graduate students, but has also generated a flurry of offers of collaboration, resulting in a spectrum ranging from the very fruitful (e.g., with *National Geographic*) to the sensitive, requiring diplomacy ("No, you can't have ALL our data, but we can talk about what you actually need, and which you can use given that you give proper credit"). They establish that the *Sea Around Us* has become an internationally respected player in both the scientific and policy arenas of global fisheries. Not too bad for a ten-year old!

I conclude by thanking the members of the *Sea Around Us*, both past and present, for their good work, and the Pew Environment Group, and its Director, Dr Josh Reichert, for the trust they put in us.

DANIEL PAULY
Principal Investigator
Sea Around Us
Vancouver, B.C.

INTRODUCTION

The *Sea Around Us* is devoted to its goal of assessing the impact of fishing on the world's marine ecosystems, and to devise policies that can mitigate and reverse harmful trends whilst ensuring the social and economic benefits of sustainable fisheries. This goal, although explicit at the onset of the project, in mid 1999, has taken a more definite shape as it evolved over the past ten years, which now encourages us to look at what is ahead.

This report presents the narrative of the project from its inception, and gives a broad overview of the main products so far generated. For the full description of the methods used in our databases as well as a host of complementary datasets, please see the *Sea Around Us* website, www.seaaroundus.org.

The *Sea Around Us* has continued to be extremely successful in reaching its primary audience, the scientific community, which we reach through articles in leading scientific journals. Since 2000, the *Sea Around Us* team members have published or co-authored over 160 articles in peer-reviewed journals (Figure 1; Appendix 1). We reached broader audiences through public interest magazines, a huge number of interviews with newspapers, magazines, radio and TV programs, and documentary films (see Synthesis Policy and Outreach section, Table 1 for examples), and through extensive lecturing to groups ranging from delegates to the World Trade Organization in Geneva to high school students in Belize City. These efforts have been widely recognized in the press, by our peers in the scientific community, and by an increasing number of NGOs and government agencies. This report is intended to be a concise assessment of the Project's accomplishments to date. For full details of the *Sea Around Us* members, output, and communication, please visit our website, www.seaaroundus.org.

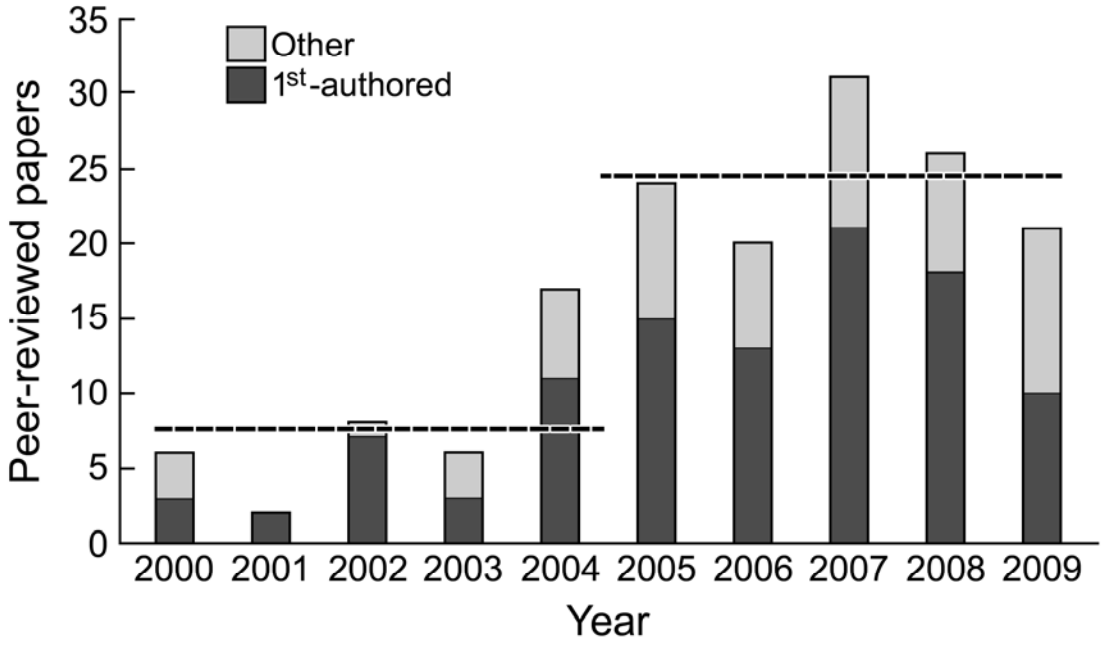


Figure 1 Number of peer-reviewed articles with *Sea Around Us* members as first (black) or co-authors (grey), 2000-2009. Note the more than threefold increase in the second 5-year period relative to the first.

TOP 10 ACCOMPLISHMENTS OF *SEA AROUND US*, 1999-2009

1. Created the first database in the world that assigns catch and derived information, such as catch values, to the areas where they originated, i.e., the Exclusive Economic Zones of specific countries, and Large Marine Ecosystems. This work, led by Dr Reg Watson, has made the *Sea Around Us* website (www.seaaroundus.org) the key source of spatialized fisheries information for the international scientific and environmental communities, accessed by thousands of users every month, and used for a wide range of products.

2. Mapped global marine fisheries catches since 1950 using a novel methodology, and established in the process that China, by over-reporting its catches, had masked a global decline of fisheries catches that started in the late 1980s. These results, published in the journal *Nature*, and later tacitly endorsed by FAO, provided the background for discussions about the global crisis of fisheries, e.g. as part of the Millennium Ecosystem Assessment.

3. Debunked, via reports presented at meetings of the International Whaling Commission and a 'policy forum' article in *Science*, the assertion promoted by the pro-whaling community that marine mammals and fisheries globally compete for fish and therefore that the culling of whales would make more fish available for human consumption.

4. Estimated the extent of subsidies to the fishing industry on a global basis and by subsidy type. Dr Rashid Sumaila, in collaboration with *Oceana*, an environmental NGO, was able to introduce these findings into WTO negotiations aiming at eliminating capacity-enhancing subsidies to fisheries.

5. Produced a series of papers investigating the successes and limitations of consumer awareness campaigns. This work, led by then Ph.D. student Jennifer Jacquet, was among the first to question the effectiveness of consumer awareness campaigns on the seafood industry, and highlighted obstacles to these efforts, such as product mislabeling, and lack of metrics for measuring campaign effectiveness. Some of the market-based alternatives presented by the *Sea Around Us* have attracted the attention of several campaign groups.

6. Developed and applied a methodology for 'reconstructing' catch statistics from coastal countries, which generally yielded catch estimates much higher than those reported by the FAO. Catch reconstructions, led by Dr Dirk Zeller, have been or are being completed for more than 80 countries. Results typically show that 'small-scale' fisheries contribute far more to the food security of developing countries than previously assumed, highlighting the need for a reassessment of policies that conventionally marginalize such fisheries.

7. Simulated, for the first time, the effect of climate change on fisheries and marine ecosystems on a global scale. Led by post-doctoral researcher Dr William Cheung (now a project collaborator based at the University of East Anglia, UK), the *Sea Around Us* demonstrated in a continuing series of papers how increases in ocean temperatures may lead to massive shifts in marine biodiversity and estimated 'catch potentials' of coastal countries.

8. Developed, using the Ecopath with Ecosim software, a technique for integrating global ecological and fisheries datasets. The development of this "database-driven construction of ecosystem models", led by Dr Villy Christensen, may represent the most data-intensive integration in marine ecology today. It will be used in 2010 and beyond to derive time series of biomass and related information for all ecosystems in the global ocean, from 1950 to the present, and for projections under various global change scenarios.

9. Supported its principal investigator and main spokesperson, Dr Daniel Pauly, as he became recognized as a leading voice for ocean conservation, as evidenced by his being awarded, e.g., the International Cosmos Prize (Japan, 2005), the Volvo Environment Prize (Sweden, 2006), the Excellence in Ecology Prize (Germany, 2007), the Ramon Margalef Prize in Ecology (Spain, 2008), and numerous honorary doctorates.

10. Overall, the *Sea Around Us* turned into a respected voice on fisheries science, conservation, and policy. The Project, besides having published numerous influential reports and other non-peer-reviewed publications, has published or participated in over 160 articles in the peer-review literature since 2000 and the publication rate of our first five years more than tripled in the second 5 years to 25 peer-reviewed articles per year, with many highlighted in the media.

THE NARRATIVE OF *SEA AROUND US*

The Global Ocean as a Layered Challenge

The *Sea Around Us* project (henceforth: *Sea Around Us*), was given at its creation, the following questions to answer by Joshua Reichert, Director of the Pew Environment Group:

- *What are the total fisheries catches from marine ecosystems, including reported and unreported landings and discards at sea?*
- *What are the biological impacts of these withdrawals of biomass for the remaining life in the ecosystems?*
- *What would be the likely biological and ecological impacts of continuing current fishing trends?*
- *What were the former states of these ecosystems before the expansion of large-scale commercial fisheries?*
- *How do the present ecosystems rate on a scale from 'healthy' to 'unhealthy'?*
- *What specific policy changes and managements measures should be implemented to avoid continued worsening of the present situation and improve the 'health' of [marine] ecosystems?*

Ten years later, we do have answers to these questions, if tentative and/or contested ones in some cases (see e.g., Figure 2; Box 1).

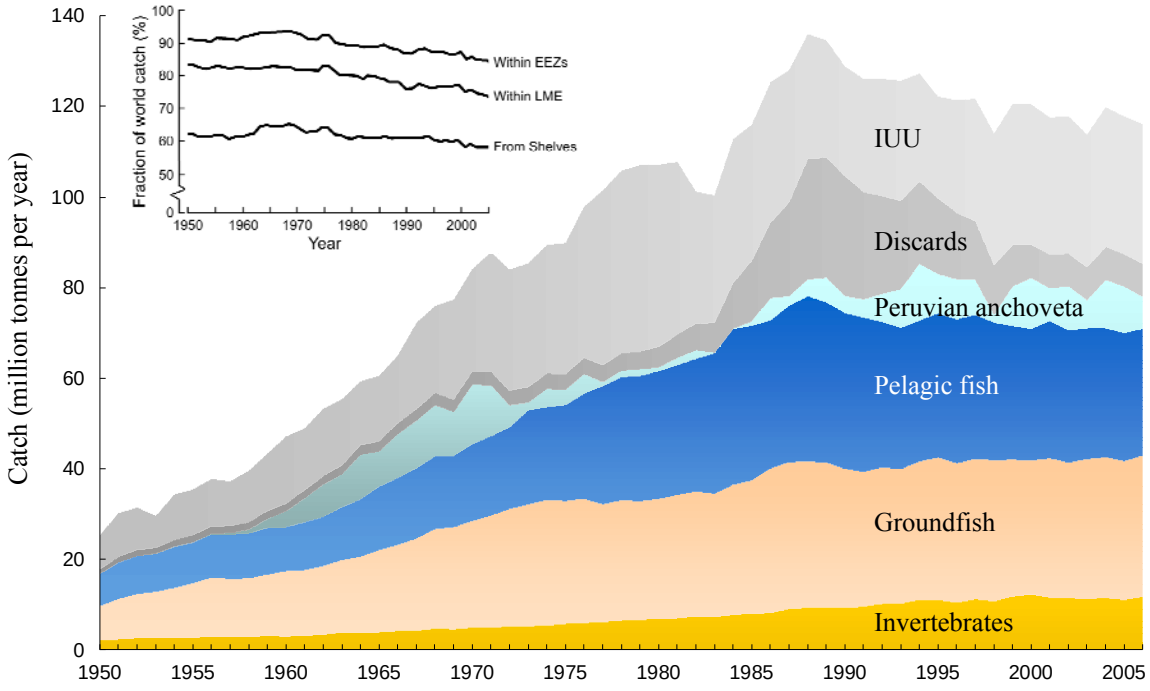


Figure 2. Estimated world marine fisheries catch, showing (as insert) the time series fraction of that catch originating from shelves (waters above 200 m), from Large Marine Ecosystems (see also Figure 3) and from the EEZs of maritime countries (up to 200 nm offshore, and accounting for about 40 % of the world's ocean). The catch itself consists of the major groupings (invertebrates, groundfish, pelagic fish and Peruvian anchoveta [*Engraulis ringens*]) in FAO landing statistics, adjusted for over-reporting by China (Watson and Pauly 2001), to which estimates of global discards (based on Zeller and Pauly 2005) and IUU catches (Illegal, Unreported and Unregulated, based on Pauly et al. 2002) were added.

Box 1: What's the catch?

Since 1950, FAO has compiled, from every country, reported fisheries landings and related data broken down into weight by taxa as well as spatially, by 18 large statistical areas. This database, known as FishStat (see www.fishstat.org), has served as the primary source for many global and regional studies evaluating and interpreting global fisheries trends. However, the *Sea Around Us* has shown that a sizeable fraction of the data presented by FAO are problematic. Therefore, in addition to demonstrating that China was over-reporting its fisheries catches (and thus exaggerating the world catch; Watson and Pauly, 2001), the *Sea Around Us* has developed and applied a methodology for 'reconstructing' real catches from coastal countries based on detailed analysis of the grey literature and the liberal use of interpolation (Pauly, 1998; Zeller et al., 2007; Zeller and Pauly, 2007). *Sea Around Us* catch reconstructions, led by Dirk Zeller, are completed or underway for more than 80 countries and will provide a more comprehensive portrayal of historical small-scale fisheries than what is otherwise available. Such reconstructions have shown, for example, that Tanzania's official reported fisheries data excludes all catches for Zanzibar, despite this island group having a dedicated fisheries agency collecting data. Due to such underreporting, actual total catches taken by Tanzanian fishers are around 70% higher than official statistics lead one to believe (Jacquet and Zeller, 2007). However, missing catch data are not only an issue for developing countries. Recent work conducted by *Sea Around Us* illustrates that the fisheries of the nine highly developed costal countries surrounding the Baltic Sea appear to catch over 30% more than is reported by the countries' official statistics. Our approach to deriving total catch time series estimates shows that the incorporation of historical 'anecdotes' (i.e., isolated observations) and local studies in catch reconstruction can provide crucial baselines (e.g., Zeller et al. 2006a, Zeller et al. 2007, Jacquet et al. 2008). We intend to make all our reconstructed catch datasets available through the *Sea Around Us* website, and contrast them with 'official catches'.

There are numerous ways the work which led to these responses could be presented. Earlier accounts have focused on one area analyzed in depth, i.e., the North Atlantic (Pauly and Maclean 2003), on methodological aspects (*Sea Around Us* 2005), or on its gradually expanding geographic coverage (Pauly 2007). Here, we have chosen to emphasize the broad conceptual scope of the *Sea Around Us*, illustrated through a series of global 'layers', each representing a data type we used and/or contributed to, and which, when jointly analyzed, represent the entire range of ocean issues (Figure 3). Here, we start with the physical and/or structuring layers, then move gradually up into the realm of resources, and the policies used (or which ought to be used) for managing their exploitation. In the process, we show how we have sought to address the challenge that the six questions above represented, and, specifically, how we are answering them.

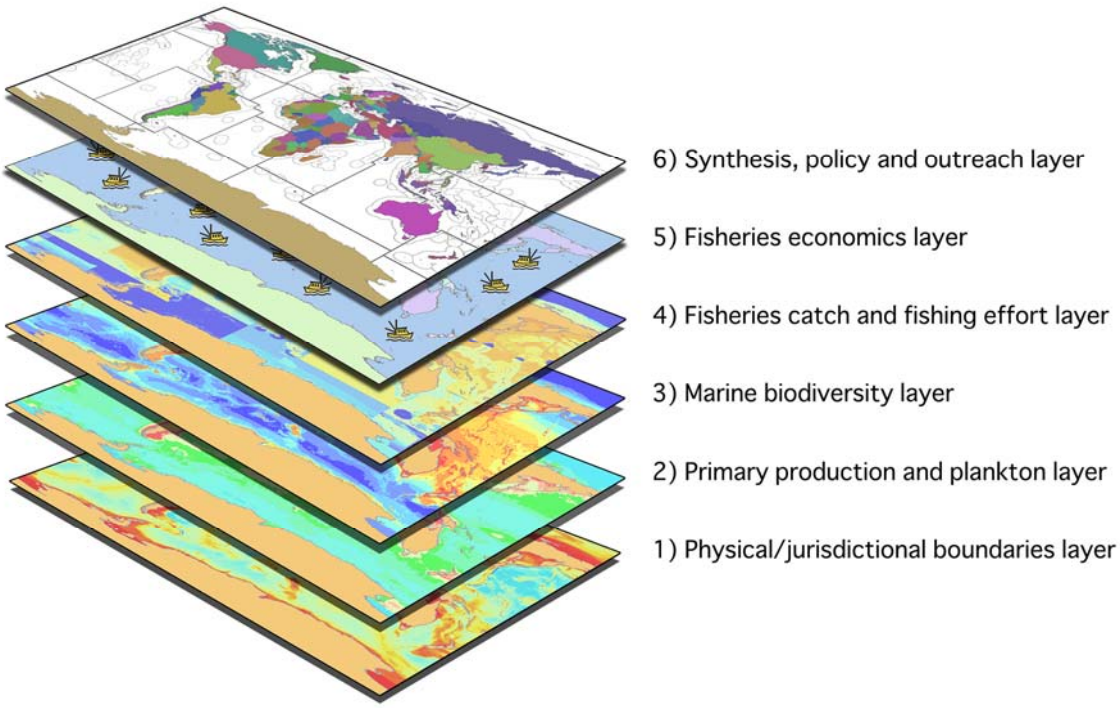
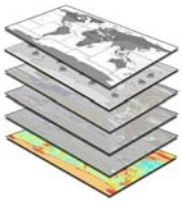


Figure 3 Illustrating the scope of the *Sea Around Us* through global 'layers', each representing a type of data used and/or contributed to, and which, when jointly analyzed, represent the entire range of ocean issues.



1. PHYSICAL AND JURISDICTIONAL BOUNDARIES LAYER

Bathymetry, Estuaries and Seamounts

Most *Sea Around Us* products are structured around various representations of ocean space, including its bathymetry. In fact, depth is possibly the most important feature in the sea, as it is the main driver of the differences in productivity between highly productive shallow and inshore waters, and the desert-like condition of the deep ocean, where islands and seamounts function as oases.

For most of our global work, we define ocean space using a grid system of about 180,000 half-degree latitude/longitude spatial cells. For depth data, however, we use a bathymetry map by the US National Oceanic and Atmospheric Administration (NOAA 2004), which presents depth data at a higher spatial resolution, providing us, at the Equator, with nine depth soundings per spatial cell.

Along coastlines, one of the most important features is estuaries, where the freshwaters discharged from rivers meet the sea, creating highly productive terrestrial and aquatic habitats. To account for these (e.g. during our 'catch allocation', see below), we created an expanding database of over 200 of the world estuaries which account for over 80% of the riverine input to the world ocean and in which each maritime country is represented through at least one estuary, however small (Alder 2003).

The waters with depths down to approximately 200 meters comprise the continental shelf. These waters represent the most productive areas of the world's ocean and presently account for about 60% of the global fisheries landings in 2001 (Figure 2). Beyond the continental shelves lay the continental slopes, ranging between 200 to 500 meters in depth. These waters represent areas in which fisheries are

increasingly expanding into (Pauly et al. 2005; Morato et al. 2006). Beyond the continental slopes, the waters are generally too deep for bottom fisheries, though some pelagic fisheries do occur in these regions. Exceptions are the seamounts, underwater volcanoes that reach heights of more than 1000 meters from the ocean floors, generating areas of high productivity and biodiversity above their summit. Various regional estimates on the number of seamounts did previously exist. However, it was the *Sea Around Us* that first published, using a detailed analysis of the NOAA bathymetry maps (Kitchingman and Lai 2004; Kitchingman et al. 2007), a global estimate of the number (approx. 14,000) and the locations of the world's large seamounts (Morato and Pauly 2004). Our seamount database is being used by numerous marine researchers and NGOs, and, along with our other related analyses on seamounts (see contributions in Morato and Pauly 2004), has contributed to the issue of seamount resource conservation. The database has proved to be also beneficial for our fisheries catch allocation, which now uses presence on seamounts as one of the allocation criteria (Close et al. 2006).

Exclusive Economic Zones

The most important jurisdictional boundary in the sea is not the territorial seas - the small, 12 nautical mile wide band of territorial waters that formally belong to maritime countries - but their Exclusive Economic Zones (EEZs) which, according to the UN Convention on the Law of the Sea, confer sovereign rights to natural resources within the water up to 200 nautical miles from the shoreline. Altogether, about 40% of the world's ocean is claimed as EEZs and because they usually include the highly productive continental shelves, over 80% of the global marine fisheries catch is presently taken within these EEZs (Figure 2). Thus, for a project such as the *Sea Around Us*, these boundaries are of the highest importance, as they enable us to associate marine areas to coastal countries, even if some of these boundaries are contested among some of these countries.

The first EEZ boundaries dataset that the Project used was acquired from a commercial enterprise, thus causing difficulties in distributing our datasets through our website or even for our scientific collaborations. The issue has since been resolved through collaboration with the Flanders Marine Institute, which created a public domain version of these boundaries (www.vliz.be/vmdcdata/marbound). The use of this new EEZ database has resulted in greater exchanges of data with our colleagues, notably those working on FishBase (www.fishbase.org) and SeaLifeBase (www.sealifebase.org), as well as allowing us to further delineate EEZs based on ecological considerations (for example, differentiating the US EEZ into the Atlantic Coast, Gulf of Mexico, Pacific Coast and Alaska).

Large Marine Ecosystems

Another level of aggregation for the global work of the *Sea Around Us* are the Large Marine Ecosystems (LMEs), of which 66 have so far been defined (Figure 4). LMEs are "relatively large areas of ocean space of approximately 200,000 km² or greater, adjacent to the continents in coastal waters, where primary productivity is generally higher than in open ocean areas, […] and whose boundaries are defined by: (i) bathymetry, (ii) hydrography, (iii) productivity, and (iv) trophic relationships." (www.lme.noaa.gov/).

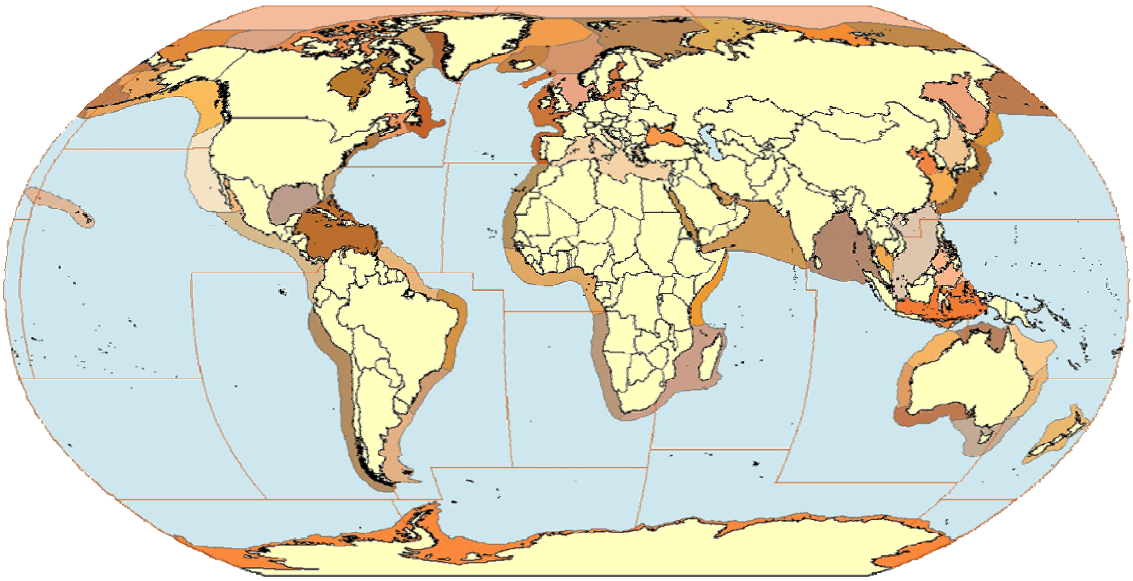
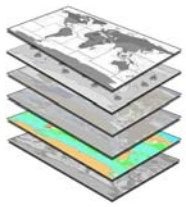


Figure 4 The world's 66 presently recognized Large Marine Ecosystems (which, because of their coastal nature, presently encompass well over 70% of the world marine fisheries catch), superimposed on the 18 statistical area which FAO uses to report that catch.

As the LMEs defined so far are overwhelmingly coastal, LMEs account for the bulk of the world's fisheries catch (Figure 2). Moreover, their number, intermediate between FAO's 18 statistical areas and the several hundred 'chunks' of EEZs which must be considered when dealing with jurisdictional issues, make the LME scale convenient for stratifying global analyses (Pauly et al. 2008).

Thus, by grouping its half degree cells by LME, the *Sea Around Us* can output, e.g., catch time series by LME, and we have used this opportunity for many of our products (e.g., Christensen et al. 2008, 2009; Wood et al. 2008), besides having been able to contribute to global efforts aimed at documenting the status of the world's LMEs (Sherman and Hempel 2008; Pauly et al. 2008).



2. PRIMARY PRODUCTION AND PLANKTON LAYER

This layer is concerned with organisms and processes at the bottom of marine food webs: the microscopic algae (phytoplankton) generating the primary production upon which all other living organisms depend, and the zooplankton that feed on the phytoplankton.

Most of the primary production data we use were derived from the SeaWiFS satellite observation (http://seawifs.gsfc.nasa.gov/SEAWIFS.html), and up to now consisted of 12 monthly maps (October 1997 – September 1998) pre-processed by the EU Joint Research Center (JRC), Ispra, Italy, with some of the data gaps filled by interpolation (Lai 2004). However, we received 10 years worth of monthly SeaWiFS data from the JRC in late 2009, which will replace the limited data used so far.

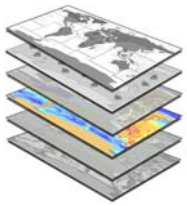
Primary production can be used, among other things, to estimate the 'footprint' of fisheries, where fisheries catches are re-expressed as primary production equivalent and compared with observed primary production to determine, e.g., for each EEZ and LME of the world, the proportion of primary production

required by fisheries (Pauly and Christensen 1995). Such estimates can be used to assess the reliability of catch data (Pauly et al. 2008; Dulvy et al. 2009) and to provide a convenient metric for comparing the impact of fish consumption on marine ecosystems, an area of research that is currently undertaken by the Project in collaboration with *National Geographic*.

The *Sea Around Us* also relies on modeled primary production data, generated by our collaborators at Princeton University, led by Dr Jorge Sarmiento. This dataset covers the time period from the late 1950s to the present and beyond (as predicted primary production). We have used these data in our work on predicting the effects of global warming on marine biodiversity (Cheung et al. 2009a) and fisheries catches (Cheung et al. 2009b), two themes to which we shall return.

The *Sea Around Us* also digitized a synthetic map published by FAO (1972) which describes zooplankton biomass estimates of the world based on Bogorov et al. (1968), and is being used to initiate the zooplankton abundance estimates in database-driven model construction (Christensen et al. 2008, and see below). Moreover, we developed distribution maps of some exploited zooplankton groups (e.g., Antarctic krill *Euphausia superba*, Akimichi shrimp, *Acetes indicus*), used in conjunction with the range maps for over 1000 other marine species in the our global warming studies (see below).

3. MARINE BIODIVERSITY LAYER



Numerous animals make use of the habitats and primary production mentioned above. We give access to knowledge about these animals through agreements and collaboration with FishBase (www.fishbase.org), which documents the distribution, ecology and other biological features of all marine fishes in the world, and SeaLifeBase, which does the same for non-fish animals (www.sealifebase.org), ranging from marine mammals and seabirds to other vertebrates (whose coverage is complete) and to the invertebrate tribes, whose coverage is at present about half of their estimated number of species (≈ 200,000).

Our work on biodiversity, which is coordinated by Dr Maria 'Deng' Palomares, has been documented in various *Sea Around Us* contributions, e.g., for countries ranging from Namibia (Palomares and Pauly 2004) to the Philippines (Pan et al. 2008), or for the High Sea (Cheung et al. 2005), and also include inferences on past biodiversity (Palomares et al. 2006, 2007). However, the part of marine biodiversity that receives most of our attention are the more than 1,000 species that are reported as part of the fisheries catches of at least one FAO member country, thus representing a subset of diversity that is documented as commercially exploited (see below for marine mammals and seabirds). We have mapped the distribution ranges of these over 700 fish and 300 invertebrate species, and made them available on our website. These distribution ranges are extremely important for our work as they are used for the allocation of fisheries catches to aforementioned spatial cells (Watson et al. 2004; Close et al. 2006) and the prediction of their future distribution and catch potential under various global change scenarios (Cheung et al. 2009b). The number of species for which we make distributions available is steadily increasing, as the number of species targeted by fisheries increase, and the taxonomic resolution of catch statistics improve.

Another element of the marine biodiversity layer is our explicit consideration of marine non-fish vertebrates (i.e., marine mammals, seabirds and marine reptiles) and invertebrates, including jellyfishes, about which we have created a vast database of biological characteristics, for example trophic levels and growth parameters (see e.g., Palomares and Pauly 2008, 2009), as required for ecosystem modeling, and available through SeaLifeBase. This includes the 351 species of seabirds, which jointly consume annually about 100 million tonnes of fish per year and must therefore be taken into account when addressing issues of trophic interactions in the sea. Each of these bird species has its own distribution map, which includes

foraging ranges (during and outside the breeding season) and is connected to a database of diet composition and population estimates, allowing their interaction with fisheries to be studied (Karpouzi et al. 2007). The *Sea Around Us* has a similar database for the 115 species of marine mammals, which have been used for various assessments of their interaction with fisheries (see Box 2).

BOX 2: The *Sea Around Us* and the science of the 'whales-eat-our-fish' campaign

The current worldwide moratorium on commercial whaling is one of the most contested issues among member countries of the International Whaling Commission (IWC). For years, the Japanese delegation to the IWC has argued that reducing the number of whales via cull would improve fisheries catch because whales are eating fish that would otherwise be available for human consumption (see e.g., Komatsu and Misaki 2003.). Some IWC members, mainly from West Africa, the Caribbean and the South Pacific, have (been) bought into such logic and have endorsed various pro-whaling proposals intended to resume commercial whaling under the pretext that recovering whale populations are a threat to their food security.

Two reports, based on works by former graduate students of Dr Pauly, were presented at the IWC meetings, first in Sorrento, Italy (2004) and second in Santiago, Chile (2008), to counter this unfounded rationale for whaling. Commissioned by the Humane Society of the United States (HSUS), the first report established that the overwhelming majority of marine mammal consumption, and especially consumption by whale species, is on fish species that are not suitable for human consumption, and/or occur in areas or depth that are not commercially viable for fisheries (Kaschner and Pauly 2004). The second report, again commissioned by the HSUS, argues that the main competitors for fish, to the developing countries supporting the pro-whaling initiatives on the basis of food security, are the markets of industrialized countries, including Japan, rather than whales that generally stay in tropical waters for calving and, thus, are not feeding (Swartz and Pauly 2008). Several other publications on the issue were presented (e.g., Pauly 2008; Kaschner and Pauly 2005; Kaschner et al. 2006), culminating with a 'Policy Brief' article in *Science* (Gerber et al. 2009) demonstrating that even a complete eradication of baleen whales in West Africa or the Caribbean would not result in increased catches. These reports all argued that improvements of the fisheries in these regions can only be achieved by addressing the real issues of overexploitation and that turning whales into scapegoats will only prolong the mismanagement.

Finally, we should mention that in 2004, the more than 190 member countries of the Montreal-based Convention on Biological Diversity (CBD) endorsed the Marine Trophic Index as one of the 8 indicators for "immediate testing" to monitor trends in global marine biodiversity (CBD 2004). This indicator, based on the observation that fishing down marine food webs is widely occurring (Pauly et al. 1998; review in Pauly and Watson 2005), is now used throughout the world and one of the products most widely associated with the *Sea Around Us*, along with the underlying 'fishing down' concept (Figure 5).

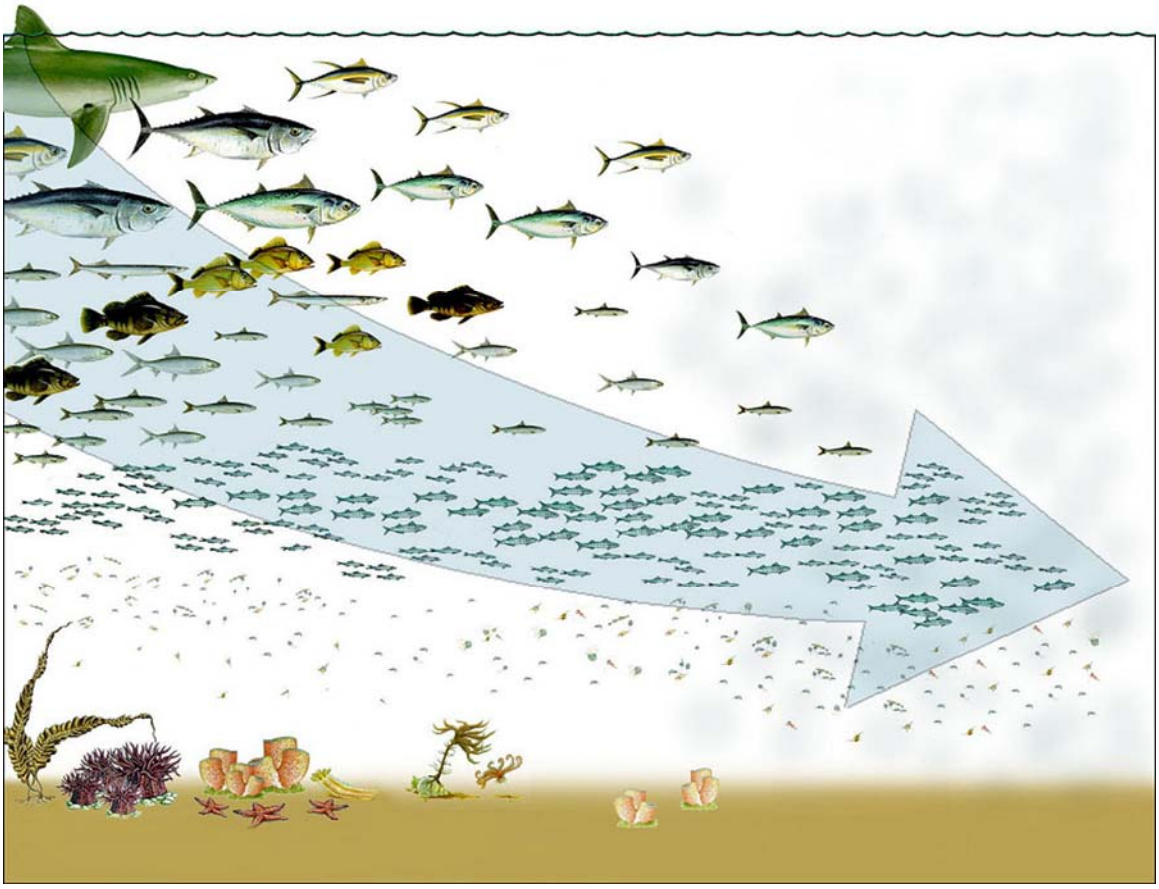
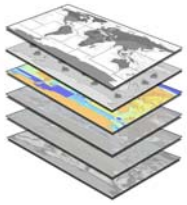


Figure 5 Schematic representation of 'fishing down' (Pauly et al. 1998). This drawing, which illustrates much of the work of the *Sea Around Us*, and which is now frequently reproduced (including in textbooks) was drawn in 2000 by Ms Raquel 'Aque' Atanacio, based on a design by Daniel Pauly.

4. FISHERIES CATCH AND FISHING EFFORT LAYER



The ability of the *Sea Around Us* to infer global trends of fisheries is due to it having re-expressed the annual reported fisheries catches (or more precisely 'landings', see below) of all maritime countries from 1950 to the present in the spatial grid described above. This was achieved, as documented in Watson et al. (2004), by assigning reported catches from FAO, ICES, NAFO and other international agencies into over 180,000 half degree spatial cells using a series of constraints including the statistical areas used in the original datasets (e.g. FAO statistical areas), the known distributions of the exploited species in question (see above) and a database of fishing access arrangements, developed by J. Alder, W. Swartz, and others, and which provides information on the operations of distant water fishing fleets in the waters (or EEZ) of maritime countries. This is complemented by a database of illegal access, which had been also used to examine the global scope and drivers of illegal fishing (Sumaila et al. 2006), a component of Illegal, Unreported and Undocumented (IUU) fishing. (See also Box 1 on the topic of 'catch reconstructions' for coastal artisanal and recreational fisheries, which probably documents the most important component of IUU catches).

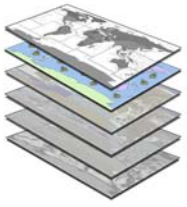
This spatial disaggregation method, which has been refined since it was first implemented and validated with local datasets (for example for Mauritania; Gascuel et al. 2007), enables the *Sea Around Us*, via its website, to represent global fisheries catches as a series of maps based on their likely origin. Thus, this unique database can also estimate catches taken from any given unit of space, e.g. EEZs, as opposed to tabular catch reports based on the national flags of fleets. This high spatial resolution of fisheries catch is what enables us to draw inferences on the impacts of fisheries on LMEs and other ecological units (Pauly et al. 2008). A large number of high-impact papers have been published based on our spatially disaggregated catch dataset, some with *Sea Around Us* members as co-authors (e.g., Halpern et al. 2008; Worm et al. 2006, 2009), some not (Costello et al. 2008; Essington et al. 2006: Hall and Schlenker 2008).

Full analysis of the time series of annual catch maps generated by the *Sea Around Us* requires independently derived maps of spatialized fishing effort at the same spatial resolution, which are not available for more than a few fisheries, and certainly not on a global basis. A preliminary analysis of port-based fishing effort, for the period from 1970 to 1995, a period of global fisheries expansion, was performed by Gelchu and Pauly (2007). This showed that, during a period in which global effective fishing effort grew by 500%, the Catch Per Unit of Effort (CPUE) in the EEZs of the world declined by an average 70%, which is compatible with earlier accounts of widespread depletions (Christensen et al. 2003; Myers and Worms 2003). In addition to the offshore range expansion, the results of this work also confirmed the common perception that the centers of fish catch and effort concentrations gradually moved southward.

Dr Reg Watson is now expanding upon this preliminary analysis, both in terms of temporal coverage, from 1950 to the present, and in terms of gear types, which now includes non port-based fleets (i.e., distant-water fleets). We envisage that the maps of cumulative fishing effort (expressed, e.g., in kilowatt-hour), will help resolve debates on the level of biomass depletion in the world ocean from 1950 to the present. Such maps will also be invaluable in modeling biomass change in the world ocean (see below).

An aspect of fishing that is often overlooked is that fishing consumes a lot of energy, especially in the form of subsidized diesel oil. Gelchu and Pauly (2007) estimated that fuel consumption of the port-based global fishing fleet grew by 2.2% per year during the period 1975-2000, confirming Pauly et al. (2003), who showed the similarity between the 20th century trajectory of world catch and that of global oil production.

This close relationship between fuel use and catch was further analyzed by Tyedmers et al. (2005), who also found that trawlers consume more fuel than other gear types. This is why, in mid-2008, when fuel prices soared, it was mainly trawling companies that were most financially affected. In fact, the utter dependence on subsidized fuel by trawlers, particularly deep-sea trawlers, highlighted in Sumaila et al. (2008), may lead to phasing out of such fishing practice when fuel prices surge again, as they surely will. The elimination of harmful fuel subsidies to industrial fishing fleets may also enable small-scale fishers to be more competitive, an important step toward sustainability (Jacquet and Pauly 2008, and see below).



5. FISHERIES ECONOMICS LAYER

Fishing is obviously not done (only) to supply people with seafood, but also for people to earn an income, and profits where possible. The *Sea Around Us* has worked, globally, on two aspects of the economics of fishing that directly impact on the ability of fishers to benefit from fisheries: (i) the ex-vessel value of the catch, and (ii) the extent of the subsidy that the fleet might receive from government, relative to the cost of fishing (due to fuel [see above], depreciation, crew wages, etc.). The *Sea Around Us* created a database of ex-vessel prices (i.e., the price received on dock sale, similar to farm gate prices in

agronomy), because no database of ex-vessel price existed that could be utilized for the purpose of the Project, i.e., on a global scale, with taxonomic and national classifications corresponding to our catch database (FAO's estimations of ex-vessel values are computed on highly aggregated data and are not downward compatible with their own landing database).

This huge compilation of ex-vessel prices, assembled from specialized literature covering the major fishing countries and important species of five continents, provided specific prices for 80% of the global catch (Sumaila et al. 2007). For the remaining 20%, a procedure was created which inferred fish prices for the many other species and/or in countries with small catches, based on taxonomic affinities and geographic proximity to the species for which prices are available. These prices (observed and inferred) were then deflated using country-specific consumer price indices (CPI) provided by the World Bank, and expressed in year 2000 real dollars. Detailed ex-vessel prices, combined with our catch database enable us to estimate the landed value of marine fisheries for each country in the world from 1950 to the present. Time series of landed value are available through our website, which have been used in numerous publications by *Sea Around Us* members (Cullis-Suzuki and Pauly 2008; Sumaila et al. 2008) and other groups (see, e.g., Pilling et al. 2008; World Bank and FAO 2008).

Estimates of fisheries subsidies were available for a number of countries (e.g. OECD and Asia-Pacific countries), but had been largely lacking for the rest of the world, and thus a reliable global estimate was not available. By scaling subsidies given in some well-documented countries to the catch value of their fisheries, it was possible to estimate the mean 'subsidy intensity' of groups of countries, and thus to infer the subsidies given in countries with similar economic characteristics that do not report on them. Global subsidies to fisheries were estimated as USD 27 billion per year (Sumaila et al. 2009). In addition, by differentiating between types of subsidies, it was possible to identify the amount of 'harmful' subsidies, directly contributing to increases in fishing capacity (USD 16 billion per year). This work has led to our estimates of fisheries subsidies replacing a lower earlier estimate produced by the World Bank, and has shaped several meetings of the Doha Round of WTO negotiations. Dr Rashid Sumaila was also invited to meet the WTO Director-General, Mr. Pascal Lamy to further discuss the issue (Figure 6).

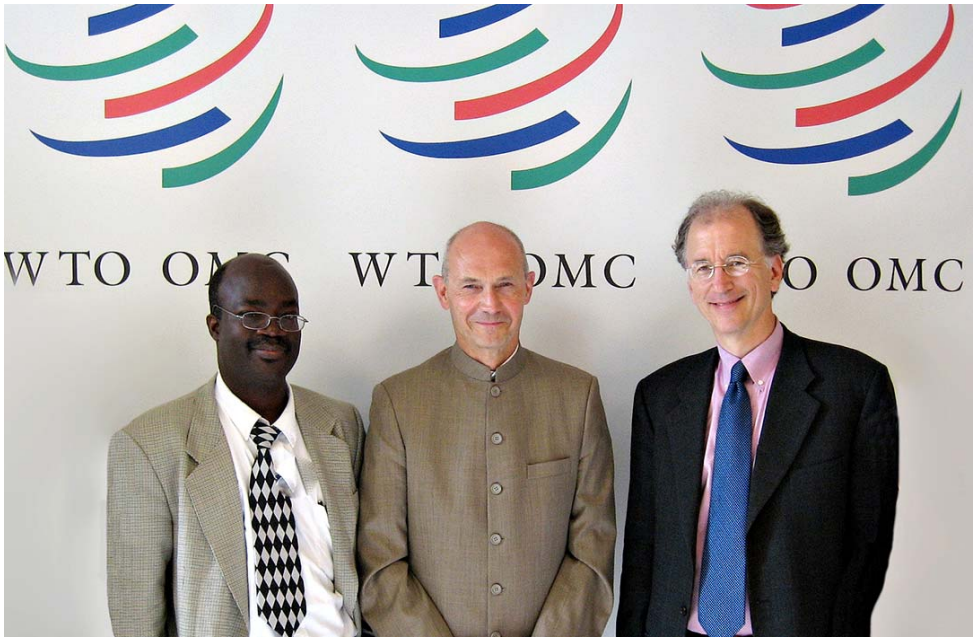


Figure 6 Rashid Sumaila of the *Sea Around Us* with Pascal Lamy (Director-General of the WTO) and Andrew Sharpless (CEO of Oceana) in Geneva in 2007.

Activities dependent on healthy marine fish populations make significant contributions to the global, regional, and national economies of countries of the world. This includes extractive uses such as commercial and recreational fishing (see Box 3), as well as non-extractive uses such as tourism. The ocean fisheries economy also includes related activities such as seafood processing, shipping, marketing, and retail sectors (Christensen 2009), as well as public sector activities such as fisheries management. In addition to direct economic values, the oceans also provide a number of indirect or non-market values such as ocean processes that influence climate and biodiversity, and bequest and existence values (Berman and Sumaila 2006).

Box 3. The Global Ocean Economics Project

The Global Ocean Economics Project began with a planning meeting in May 2007 to develop a research strategy, and the first stage of the project is now completed. In addition to the re-estimation of global subsidies to fisheries, discussed in the main text, its key findings were:

- Estimation of potential catch losses due to unsustainable fishing in all countries' Exclusive Economic Zones (EEZs) and on the High Seas since 1950. For 2000, global losses amounted to about 10 - 25% of the actual tonnage landed or a net present value of US$7.5-22 billion. Further, had this overfishing been averted, 19 million people globally could have met their food calorie requirements, thereby improving food security for many in the developing world (Srinivasan et al. 2009);
- Recreational fishing, which occurs in 118 maritime countries and involves nearly 60 million recreational anglers around the world, generated a total of about US$ 40 billion in expenditure, supporting over 950,000 jobs, while whale watching, which employs 18,000 occurs in 93 countries and territories, involves 13 million people, and generates expenditure of US$1.6 billion for the year 2000. Overall (i.e., including skin diving and related or similar activities), fish, marine mammals and marine life in general are part of the recreational activities of over 120 million people, provide one million jobs and generate US$ 47 billion in expenditures (Cisneros-Montemayor and Sumaila 2009).
- Finally, an input-output approach to estimate the direct, indirect, and induced economic effects arising from marine life (including fisheries) in the world economy. The results of this work suggest that the economic contribution of ocean fish populations was more than four and a half times larger than the value of fish at first sale—about US$380 billion per year (Dyck and Sumaila 2009).

Currently, the project is working on (i) building a global database of the cost of fishing, which will be used together with our fishing effort, ex-vessel price, subsidies, and catch values databases to estimate current profits, if any, derived from the world's ocean fisheries; (ii) determining the total number of jobs supported by marine fish populations; and (iii) assessing how the economic contributions of ocean fish populations are likely be affected under different management scenarios.

Often, fisheries managers feel pressure to sacrifice the long-term health of marine fish resources in favor of short-term economic needs of the fishing industry (Sumaila 2004; Sumaila and Walter 2005). The *Sea Around Us* thus executed a 'Global Ocean Economics Project', which, under the leadership of Dr Rashid Sumaila, helped determine the global economic contribution of activities supported by healthy fish populations, now and in the future (Box 3). The assumption here was that gaining a better understanding of the value to the global economy of healthy marine fish populations should provide a broader economic perspective for fisheries managers.

6. SYNTHESIS, POLICY, AND OUTREACH LAYER

Marine Protected Areas and other indicators

The last decades have seen the spatial expansion of fisheries — an expansion so thorough that nowadays essentially all parts in the global ocean are extensively or fully exploited by some form of fishing, notably trawling and longlining. Various international treaties, notably the Convention on Biological Diversity (CBD), have formulated targets for conservation. The *Sea Around Us* has supported this by establishing a database of marine protected areas (MPAs) whose size and location has been documented for over 4,000 individual MPAs — although they jointly cover a miniscule 0.7 percent of the world's oceans (Wood et al. 2008). It is this work that also allowed the rate of growth of surface area of the existing network of marine protected areas to be estimated, which amounts to slightly less than 5% per year, implying a doubling time of about 15 years. This means, among other things, that none of the proposed targets will be reached in time. This database, which can be accessed through the *Sea Around Us* website (and as a stand-alone database; www.mpaglobal.org), was also used to estimate the cost of maintaining MPAs (approx. $800 million per year), which can be seen as a beneficial subsidy to fisheries (Cullis-Suzuki and Pauly 2008).

Given that all MPAs so far established are within the EEZs of maritime countries, the number and size of existing MPAs can be viewed as an indicator of the seriousness with which these countries protect the fish and invertebrate resources in their EEZ. Analogous indicators, for example of how well countries protect their marine mammals (Swartz et al. 2008) or seabirds (Karpouzi and Pauly 2008), can be constructed, which can be combined with other indicators to evaluate the state of countries' EEZs (Alder and Pauly 2008). Our work on this, synthesized in Alder et al. (2009) has generated considerable international attention, and it will now be further broadened in the context of projects linking several major research institutions.

Fish we should eat - or not

In 2006, the *Sea Around Us* presented the first comprehensive, global analyses of forage fisheries, including trends in catches since the 1950s; how landings are used by humans including consumption, trade and use in food production, and the interaction between forage fisheries, humans, and marine animals (Alder and Pauly 2006).

During this study, we also modeled global atmospheric dispersion of dioxins (Zeller et al. 2006), which are known to impact on health issues in aquaculture products through the fishmeal used, e.g., in salmon farming (Hites et al. 2004). Our earlier modeling approach is currently being improved, and expanded, and applied to both dioxins and mercury. This study also provided the first estimate of the consumption of fishmeal in the aquaculture sectors of various countries since 1975, when global feed databases were initiated (Campbell and Alder 2006). A summary of this report was published in the peer-reviewed literature (Alder et al. 2008).

This work, combined with earlier work on the Peruvian upwelling ecosystem (Pauly et al. 1989) opened the door for a new collaborative project in Peru, whose fishery for the anchovy *Engraulis ringens* is the world's largest 'reduction' fishery (i.e., whose target species is used to make fishmeal and fish oil). This project will analyze the management of the Peruvian anchoveta fishery using the Ecopath with Ecosim software, the ultimate goal being the elaboration of robust management policy that take into account the status of the entire ecosystem. The project is to be led by Dr Villy Christensen in collaboration with Dr Patricia Majluf of the Center for Environmental Sustainability (CSA) of the Universidad Peruana Cayetano Heredia (UPCH) in Lima, Peru, and has strong linkages with the Instituto del Mar del Peru and support from the Peruvian Minister of Production.

A side bar, we also hope that this project will contribute to accelerating the transition of the Peruvian anchovy fishery from a pure reduction fishery to one that lands increasing quantities of anchovies for direct human consumption, which has increased from less than 1% in 2006 to over 3% in 2009. This is important because, in effect, fish presently used for fishmeal (about one-third of the world catch) is the only 'reserve' of seafood we may still have (except for jellyfish and other plankton…) - which bring us to the topic of seafood.

The conservation community has directed a lot of effort at trying to change consumer behavior when it comes to buying seafood, based on the notion that it will raise awareness, and eventually lead to sustainable fisheries, by reducing demand for overfished species. Work by the *Sea Around Us* shows that these efforts might have ignored many market impediments, including fisheries subsidies, renaming and mislabeling, and increased international demand (Jacquet and Pauly, 2007; 2008a; 2008b; Jacquet et al. 2009). This work has led to various groups re-evaluating their emphasis on the role of market-based efforts to save wild fish. It has also lead to a collaboration between the *Sea Around Us* and *National Geographic* to determine possible seafood consumption 'targets' using the concept of the 'seafood print' – the amount of marine primary production required to produce the seafood that is consumed in different countries, in analogy to the 'footprint' concept, now widely used to compare – on land – the impacts of widely different processes and impacts.

Global climate change

Global climate change and its knock-on effects on the ocean can be expected to have major impacts on marine resources and seafood supplies. The *Sea Around Us* was the first to model some of these impacts on a global basis. The Project's approach builds on the over 1000 distribution range maps of exploited marine fish and invertebrates that were painstakingly constructed to spatialize the fisheries of the world, and which represents one of its major assets. This approach was implemented in three steps:

Step 1 aims to establish a statistical model that would allow us to predict the effects of climate change on global fisheries potential. This work consisted of establishing an empirical relationship between the distribution areas of fish and invertebrate species and their potential catch (expressed as the mean of the maximum catch over a period of five years). The relationship that was established, which also includes the primary production in the distribution area of each species and their trophic level as predictor variables, has surprisingly high explanatory power and is applicable to a wide range of species, from krill and sardines to tunas and sharks (Cheung et al. 2008).

Step 2 aims to predict the responses of distribution ranges of exploited marine species to climate change. It consisted of developing a simulation model called "dynamic bio-climate envelope model" that project species distribution shifts as temperature and other ocean condition changes (Cheung et al. 2008). This model was built on the over one thousand range maps we constructed for mapping fisheries catches. From each of these maps, a temperature preference profile was derived, defined by the water preferentially inhabited by that species. Then, for each (half degree lat./long.) cell of a species distribution range map, a

population dynamics model was set up, featuring the (bi)annual broadcasting of reproductive propagules whose survival is determined largely by the water temperatures they encounter. Given increasing temperatures, this generates amoeboid poleward movements of the species in question. Led by post-doctoral researcher William Cheung, the *Sea Around Us* modeled how shifting ocean temperatures - predicted over the next fifty years with data provided by our collaborators at Princeton University - will affect 1,066 marine species. The result produces a latitudinal pattern of invasion and extirpation (Cheung et al. 2009a), migrating from tropical seas toward cooler waters at an average rate of 40 to 45 kilometers per decade.

Step 3 aims to predict the effects of climate change on global fisheries potential. Combining the prediction of catch potential from species distribution ranges in Step 1 with the species shifts in Step 2 generated a map of change in catch potential for the entire world oceans (Figure 7). The tropics are predicted to lose up to 40% of their catch while northerly waters will benefit from warming and their catches could increase by an average of 30 to 70% (Cheung et al. 2009b).

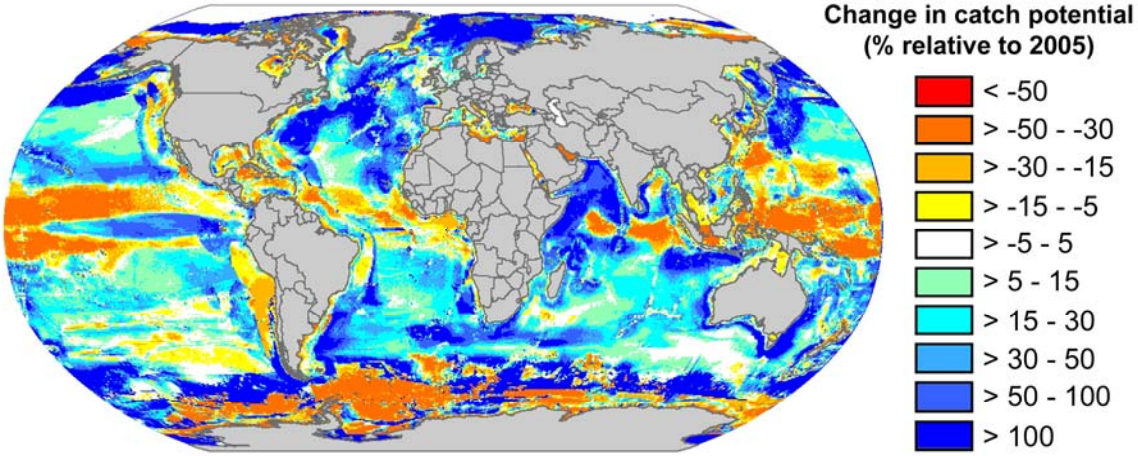


Figure 7 Predicted change in the potential of fisheries five decade hence, given the distribution range shifts induced by global warming documented in Cheung et al. (2009a). This pattern implies that high latitudes may see their catch potential increase (e.g., Iceland, Norway), while tropical countries may experience declines (Cheung et al. 2009b). However, these predictions do not account for change in oxygen distribution in, and acidification of the oceans, and hence represent an optimistic scenario.

This series of pioneering papers, which emphasize global patterns, are easily adapted to local conditions, i.e., for countries and regions, and models pertaining to the US and Australia have been prepared. Local analyses suggest, at present, that the effect of global warming will create winners (a few high-latitude countries such as Norway and Iceland) and losers (tropical countries). However, we expect that future iterations of the model will produce only losers. The reason for such pessimism is that some important factors were omitted from our model, to be included in future rounds, which are all expected to have negative effects on marine resources. This applies especially to increased stratification of the ocean, which reduces the dissolved oxygen available for fish growth (Pauly 1981, in press) and acidification, which reduces the physiological performance of all water-breathing animals (Pörtner et al. 2004).

Toward the estimation of past, present and future biomass in the sea

We have severely impacted the biodiversity of marine ecosystems. The scale of the impact is evident as the world's total fish catch has decreased over the last decades in spite of increasing effort; larger, predatory fishes (table fish!) are becoming scarce (Christensen et al. 2003; Pauly et al. 2005).

Still, the ocean remains a wilderness where the main rule is "eat, but avoid being eaten." Species interaction matters – fishing one species impacts its predators and prey, as well as its competitors, and this therefore calls for the evaluation of tradeoffs in management and conservation. Also, environmental constraints set limits for productivity, varying with climatic fluctuations. In order to analyze these interactions, we rely on quantified ecosystem models as the implications and interactions are too complex for the mind or conceptual models to grasp. The ecosystem models represent an important aspect of ecosystem-based management, which by now is widely accepted through international agreements, such as the Jakarta mandate of the Convention on Biological Diversity, the Kyoto Conference on Food Security, and the Johannesburg Declaration on Sustainable Development.

Informing ecosystem-based management is, however, a daunting task, and a reason why such management is only sparsely implemented worldwide. Ecosystem models, which are required for ecosystem-based management, are data-hungry and feeding them sufficiently calls for a thorough understanding of what information is needed, what is available, how to access it and feed it to the models, and how to perform the analysis. In addition, since new information continuously becomes available, how does one keep the models up-to-date?

Villy Christensen and his *Sea Around Us* and other collaborators, building on an approach initiated by J.J. Polovina of the US National Marine Fisheries Service in Hawaii, has developed a modeling system to respond to these challenges, and this system may represent the largest data assimilation and analysis ever conducted in applied ecology. The methodology builds on the widely applied Ecopath (or Ecopath with Ecosim; EwE) approach, which the US National Oceanographic and Atmospheric Administration (NOAA) in 2007 honored as one of the ten biggest scientific breakthroughs in its 200-year history.

EwE is used as the core of an automated methodology which extracts information for any area from an array of spatial, global databases (the 'layers' discussed previously), constructs an ecosystem model based thereon, then performs a fine-tuning process of the model. The products of this methodology are data-rich, standardized models covering the world oceans.

The methodology has been used to report on ecological and economic aspects of LMEs (Christensen et al. 2008, 2009), and for a recent study in *Science* demonstrating that fish contribute a major and previously unrecognized portion of the inorganic carbon which partly counters the ocean's tendency toward acidification (Wilson et al. 2009). From the models, we estimated the global fish biomass to be around 2 billion tonnes (with about half being little-known mesopelagic fishes) and that this biomass annually contributes around 110 million tonnes of calcium carbonate to the carbon cycle and buffers the pH of the ocean. Thus, this research shows that fish have a strong influence on mitigating the ocean acidification resulting from atmospheric carbon dioxide emissions. This is an additional argument to maintain healthy populations of fish in the oceans for the ecosystem services they provide.

The database-driven model methodology mentioned above may be the most important tool ever constructed for analyzing how life in the oceans has changed in recent history, how it may react to future environmental changes, and the consequences this may have for the world's food supply. Indicative of this is that, already, database-derived ecosystem models are being used for a number of different purposes:

- The first application of the approach was the construction of 66 models describing the world's LMEs in collaboration with the Global Environment Fund (GEF);
- An early version of the methodology was also used for the UNEP Global Environment Outlook series and other global environmental assessments to predict global adaptation and impact on biodiversity. (UNEP will use the new models for a biodiversity outlook in support of the Conference of the Parties to the Convention on Biological Diversity [CBD] meeting in October 2010);
- Similar models for the EEZs of maritime countries and of the High Sea in the three major oceans are used as a framework for the Global Ocean Economics project, and will be used to evaluate economic and social consequences of alternative management strategies under climate change;
- We cooperate with the Netherlands Environmental Assessment Agency (PBL) on environmental assessments, currently focused on a spatially explicit version of the methodology, linked to the global terrestrial IMAGE-GLOBIO models of PBL, as a first attempt to construct a global, spatially explicit, linked aquatic and terrestrial model with feedback mechanisms;
- We also cooperate with the Washington, DC-based International Food Policy Research Institute (IFPRI), which developed the IMPACT model to examine alternative futures for global food supply, demand, trade, prices, and food security. We will use database-derived models linked to the IMPACT model to cover ocean food supply and price-demand tradeoffs as part of the study 'Fish to 2030' that is to be conducted for the World Bank;
- Throughout, we will further refine database-driven modeling approach using additional information on mesopelagic fishes, gelatinous organisms (jellyfishes) and spatial fishing effort (see above) to drive the models. The short-term goal is to produce detailed estimates of how fish biomass has changed in the world oceans since 1950, while the longer-term goal is to predict how fish biomass may change because of climate change, i.e., to add a trophic dimension to global change work described above.

Outreach

While the scientific achievements outlined above are accessible to interested specialists through scientific publications, their implications for public policy are not always obvious and accessible to those concerned, e.g., politicians and their staff, NGO staffers, and the public at large. In an era with overwhelming amounts of information, how can we attract attention to the scientific work that we do? Over the past few years, the *Sea Around Us* has increased its outreach efforts (Table 1), including initiating, in 2007, the creation of a position devoted to this task. Now filled by Dr Jennifer Jacquet, this part-time position involves liaising with the UBC media office and with counterparts at the Pew Environment Group, and the preparation of press releases and other materials about our research, along with the revamping of our website to contain, in addition to data and visualizations, a section devoted to news. The *Sea Around Us* also hosts mini-workshops to help its members become better communicators both orally and visually. Between our growing reputation, improved tools, and the relationships we have fostered with journalists, the *Sea Around Us* has markedly increased our interactions with the mass media, and hence the reach of our work, and can expect to continue to have a trusted voice on issues related to marine science and conservation.

Table 1 Selected media items covering the *Sea Around Us*, 1999 to 2009 (an extensive list of such items may be found at www.seaaroundus.org/about/index.php/category/media-coverage/)

Date	Title	Featuring	Author/Outlet
Jul. 24, 1999	UBC fisheries Prof gets $2.1-million grant	D. Pauly	The Vancouver Sun
Nov. 29, 2001	Controversy over the world's fisheries stocks	D. Pauly	NPR Morning Edition (radio)
Nov. 30, 2001	Study says bad data by China inflated global fisheries yields	D. Pauly & R. Watson	Erik Eckholm, The New York Times
Feb. 18, 2002	Get ready for jellyfish sandwiches, scientists warn	D. Pauly	National Post
Jan. 21, 2003	Iconoclast looks for fish and finds disaster	D. Pauly	Carol Yoon, The New York Times
Aug. 9, 2003	A new way to feed the world	D. Pauly	The Economist
May 4, 2004	Unintentional catch wreaks havoc on oceans	A. Poon	Larry Pynn, The Vancouver Sun
Dec. 20, 2005	Fishing industry's fuel efficiency gets worse as ocean stocks get thinner	D. Pauly	Cornlia Dean, The New York Times
Jul. 18, 2007	Global fishing trade depletes African waters	D. Pauly	John Miller, The Wall Street Journal
Oct. 31, 2007	Jellyfish proliferation	D. Pauly	CBC, The Current (radio)
Jul. 9, 2008	Massive under-reporting of fish catches leads to declining stocks	J. Jacquet, D. Pauly, & D. Zeller	Steve Connor, The Independent
Jul. 24, 2008	Pacific fish catches 'vastly' underreported	D. Zeller	ABC Radio, Australia
Nov. 3, 2008	Animal feed is fishy	D. Pauly	Scientific American (podcast)
Jan. 2009	The End of the Line	R. Sumaila & D. Pauly	Sundance Film Festival (documentary)
Jan. 13, 2009	Research ties human acts to harmful rates of species evolution	D. Pauly	Corey Dean, The New York Times
Jan. 16, 2009	Fish poop helps balance ocean's acid levels	V. Christensen	The Guardian
Feb. 12, 2009	Fish migrating to cooler waters	W. Cheung	Azedeh Ansari, CNN (TV)
Feb. 17, 2009	Deep-sea trawling neither green nor profitable	R. Sumaila & D. Pauly	Catherine Brahic, New Scientist
Mar. 4, 2009	Rencontre avec Daniel Pauly, expert mondial de la pêche	D. Pauly	Gaëlle Dupont, Le Monde, France
Mar. 6, 2009	Advice to eat fish hurts environment	R. Sumaila	CBC (radio)
Apr. 9, 2009	Want to save the planet? Tuck in to some jellyfish and chips, squid sausages and algae burgers	D. Pauly	Simon Usborne, The Independent
Jul. 31, 2009	Tastier names trouble for seafood stocks	J. Jacquet	David Fahrenthold, Washington Post
Oct. 1, 2009	Call for new Nobel prizes to honour 'forgotten' scientists	D. Pauly	Mark Henderson, Times Online
Oct. 8, 2009	Tropics face fish famine due to climate change, report warns	W. Cheung	Suzanne Goldenberg, The Guardian
Nov. 17, 2009	Consumer campaigns don't save endangered fish, report	J. Jacquet	Deborah Jones, Yahoo! News

Conclusions and Outlook

The expertise that the *Sea Around Us* – which suffered relatively little staff turnover – has built over the last 10 years, combined with the rich global databases that were built in this same period, guarantee that our high productivity will, in the next years, not only be maintained, but actually increase.

We have noted above some areas of future emphasis. They will include fisheries economics and public policy, global change impacts and mitigation strategies, the further development of modeling tools for the integration of massive amounts of ecological and biodiversity information on marine ecosystems, and the identification of 'levers' for ecosystem-based fisheries management.

The *Sea Around Us* has become a leader in its field – global marine fisheries and their impact on ecosystems – because it stuck to its global mandate, without spreading its forces on trying to compete with local groups studying specific fisheries, such as e.g., the trawl fishery off New England, or the tuna purse seine fishery in the Central Pacific, or specific ecosystems, such as the Upper Gulf of California or the Mid-Atlantic Ridge. On the other hand, we do integrate data from species- or locale-specific studies into our global databases, where they help us derive global patterns.

We do hope, therefore, that we will be given the opportunity to continue working in what has proven to be a very successful 'global' mode, where the *Sea Around Us* has its unique niche.

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SEA AROUND US WEBSITE

The website of the *Sea Around Us* has seen a massive makeover in 2009; as it now stands, it gives equal emphasis to its 'newsy' side, which highlights recent project products and events, designed for the casual visitors and for journalists (www.seaaroundus.org/about/), and to its 'data' side, which emphasizes our quantitative and visual products (www.seaaroundus.org/data/).

The web pages available via the latter URL constitute the first (and still the only) website providing fisheries data pertaining to the specific areas (or ecosystems) from which catches are taken (e.g., the Exclusive Economic Zones of specific countries and Large Marine Ecosystems). The website, currently managed by Dr Dirk Zeller and Mr. Ar'ash Tavakolie, is continually updated with new catch allocations and new Project information.

The following products are freely available and searchable from the *Sea Around Us* website:

A) Information by area (EEZs, LMEs, High Seas, Global Oceans):

1) Catch (as tonnage or value) time series by spatial entities (such as EEZs or LMEs) by gear or taxonomic groupings. All data from 1950 to present (currently 2006);
2) Biodiversity information and data by each spatial entity;
3) Ecosystem information for each spatial entity, including primary production, Marine Trophic Index and FiB index, marine protected areas (MPAs), footprint analyses, and links to Ecopath models; and
4) Governance information, such as details on fisheries access agreements, fisheries subsidies, treaties and conventions, as well as links to relevant websites associated with each spatial entity.

B) Information by topic:

1) Maps, results and source material for our climate change studies, illustrating both the likely impacts on biodiversity as well as fisheries catches;
2) Information by species, presenting key information for each species that is reported as caught by fisheries (over 1,000 species), including the *Sea Around Us* distribution maps and deep-links to FishBase, SeaLifeBase and other internet data sources;
3) Marine catch maps, showing global or regional maps of fisheries catches, mapped onto our half by half degree cell structure;
4) Global MPAs, deep-linking to the only global database on marine protected areas, searchable by country;
5) Historic expeditions database, with emphasis on the fish and invertebrates that were collected during these expeditions; and
6) Pages presenting earlier topics covered by the Project, such as the 4th World Fisheries Congress, West African fisheries and the 5 year project retrospective (1999-2004).

C) Collaborator pages, showing data, information and published material for selected collaborative projects, and presently including:

1) Fisheries Economics, presenting direct links to specialized pages presenting economic data of interest, such as direct links to landed value pages for each EEZ and LME, or subsidies paid by each country to its fishing sector;
2) Convention on Biological Diversity (CBD), presenting the Marine Trophic Index (by EEZ or LME), developed and implemented in collaboration with the CBD; and
3) Baltic Sea 2020, collaboration with a Swedish foundation, which resulted in catch reconstructions for all nine Baltic Sea coastal countries.

SEA AROUND US YEARBOOK

Present (late 2009) Team Members

Dalal Al-Abdulrazzak, MSc/PhD student since 2009.

Dalal joins the *Sea Around Us* to examine the historical changes in the ecology and fisheries of the Persian Gulf and the countries surrounding this body of water. Her work will also evaluate whether the Persian Gulf qualifies as a Large Marine Ecosystem of its own.

Zoraida Alojado, Research Assistant (GIS) since 2009.

Zoraida works as Geographic Information Specialist for the *Sea Around Us*. Thus, she provides GIS services to fulfill the needs of the project, including mapping catches and other data, and works closely with the project's web developer to meet the mapping requirements of the website.

Jonathan A. Anticamara, Post-doctoral Researcher since 2009.

Jonathan is assembling and developing the global fishing effort database. Together with Reg Watson, he is mapping the distribution of global fishing effort, and analyzing (1) the spatio-temporal trends in fishing effort, and (2) the relationships between fishing effort, fish catch, and marine diversity changes.

Key Publication: **Anticamara, J.A.**, D. Zeller, and A.C.J. Vincent. Spatial and temporal variations in abundance, biomass, and diversity within marine reserves in the Philippines. *Diversity and Distributions [in press]*.

Megan Bailey, Newsletter Editor since 2008.

Megan is a PhD student working on a fisheries economics project under the supervision of Rashid Sumaila. She is the successor of Robin Forrest as editor of the *Sea Around Us* Newsletter.

Key publication: **Bailey, M.,** C. Rotinsulu, and U.R. Sumaila. 2008. The migrant anchovy fishery in Kabui Bay, Raja Ampat, Indonesia: Catch, profitability and income distribution. *Marine Policy* 32: 483-488.

Brajgeet Bhathal, MSc/PhD student since 2002.

Brajgeet completed her M.Sc. with Daniel Pauly in 2004 on historical reconstructions of Indian marine fisheries catches as basis for testing the 'Marine Trophic Index'. For her Ph.D., Brajgeet is examining the growth of fishing effort in 13 maritime areas (9 States and 4 Union Territories) of India from 1950 to the present, and related statistics (fuel consumption, cost of fishing, catch per effort), in view of mapping a sustainable future for India's marine fisheries.

Key publication: **Bhathal, B.** and D. Pauly. 2008. 'Fishing down marine food webs' and spatial expansion of coastal fisheries in India, 1950-2000. *Fisheries Research* 91: 26-34.

Shawn Booth, Senior Research Assistant; member since 2000.

Shawn works mainly on catch reconstruction and ecosystem modelling. Shawn has also been working on tracing mercury and dioxin from emission to and through the food webs of marine environments, e.g., mercury in the Faroe Plateau ecosystem. Currently, the focus of his work is to investigate the effects of wind-driven distribution of dioxins and mercury on the marine food webs. Shawn is also an M.Sc. student, supervised by Villy Christensen.

Key publication: **Booth, S.** and D. Zeller. 2008. *Marine Fisheries Catches in Arctic Alaska*. Fisheries Centre Research Reports 16(9), 59 p.

Lucas Brotz, MSc student since 2007.

Lucas is systematically collecting and analyzing reports on jellyfish outbreaks in view of testing whether their abundance has globally increased in the last decade(s), and if so, to identify the key environmental factor (whether fisheries-related or not) that may explain such change.

Brooke Campbell, Research Assistant, 2005-2007; MSc student since 2007.

Brooke was a research assistant in the *Sea Around Us*, tasked by J. Alder with developing a global mariculture production database at sub-national scale, and now an M.Sc. student. She is analyzing her database (which will eventually be posted on the *Sea Around Us* website) to identify the factors which have affected the development and expansion of mariculture worldwide since 1950. This database will enable the *Sea Around Us* to assess the credibility of current projections of future aquaculture production which many see, likely over-optimistically, as effectively replacing capture fisheries as the primary global supplier of seafood.

Key publication: **Campbell, B.** and J. Alder. 2006. Fishmeal and Fish oil: production, trade and consumption. p. 47-76 *In:* J. Alder and D. Pauly (eds). *On the multiple Uses of Forage Fish: from Ecosystem to Markets.* Fisheries Centre Research Reports 14(3).

Marina Campbell, Finance/administrative clerk since 2008.

Marina assists Ms Grace Ong in providing crucial support services to the *Sea Around Us.*

William Cheung, Postdoctoral Fellow, 2007-2008; Associated Faculty since 2009.

William, formerly a PhD student at the Fisheries Centre, developed as a post-doctoral fellow, jointly with D. Pauly, the project's main model for studying the large-scale effects of climate change on marine biodiversity and fisheries. Since early 2009, William is a close collaborator, based at the University of East Anglia, UK.

Key publication: **Cheung, W.W.L.,** C. Close, V. Lam, R. Watson and D. Pauly. 2008. Application of macroecological theory to predict effects of climate change on global fisheries potential. *Marine Ecology Progress Series* 365: 187-193.

Villy Christensen, Associate Professor; member since 1999.

Villy serves as coordinator for the ecosystem modeling activities of the *Sea Around Us,* as well as for the development of the 'Ecopath with Ecosim' (EwE; www.ecopath.org) modeling approach and software. Villy Christensen focuses on the development of ecosystem models, and to study management options for ecosystem-based fisheries management. He is presently focusing on the development of the database-driven model generation, which serves to integrate most of the data layers developed as part of the *Sea Around Us project*. He is also the Principal Investigator for the Lenfest Ocean Futures Project.

Key publication: **Christensen, V.** et al. 2009. Database-driven models of the world's Large Marine Ecosystems. *Ecological Modelling* 220: 1984-1996.

Sarika Cullis-Suzuki, MSc student, 2006-2009.

Sarika completed her MSc with Daniel Pauly in 2009 on the global effectiveness of Regional Fisheries Management Organizations (RFMOs), both on paper, as determined by the contents of their websites and other documents, and on the ground, as determined by the status of the fish stocks for which they are responsible. Both assessments (and especially the latter) suggested that RFMOs are failing to fulfill their mandates.

Key publication: **Cullis-Suzuki, S.** and D. Pauly. The high seas: a global evaluation of regional fisheries management organizations. *Marine Policy [in press]*.

Andrew Dyck, Fisheries Economist since 2008.

Andrew works with R. Sumaila on the contribution of marine fisheries to the global economy.

Key publication: **Dyck, A.J.** and U.R. Sumaila Contribution of Ocean Fish Populations to the World Economy. Fisheries Centre *Working Paper #2009-08*, The University of British Columbia, Vancouver, B.C., Canada.

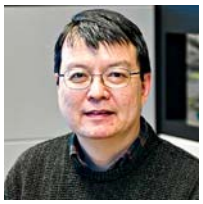
Rhona Govender, MSc student since 2009.

Rhona will work on a thesis, under the supervision of D. Pauly, devoted to an independent (non-FAO) re-estimation of the global catch of small-scale fisheries, based on the detailed examination of key statistics in maritime countries, including their demographics and the inshore areas available for artisanal fishing.

Sarah Harper, Research Assistant since 2009.

Sarah works on catch reconstructions for various regions, including the Baltic Sea, various island and territories in the Caribbean South America, and the South Pacific. She is taking on the responsibility for maintaining and updating the global fishing- access- agreement database of the Project.

Key publication: **Harper, S.**, L. Frotté, S. Bale, S. Booth and D. Zeller. 2009. Reconstruction of total marine fisheries catches for New Caledonia (1950-2007). p. 67-75. In: Zeller, D. and Harper, S. (eds). Fisheries catch reconstructions: Islands, Part I. Fisheries Centre Research Reports 17 (5).



Joe Hui, Programmer since 2007 (contractual).

Joe participated in the programming of EwE (version 6) and of EcoTroph, another tool for ecosystem modeling. He also wrote a program to analyze the dispersion of dioxins and mercury in the atmosphere and their subsequent deposition on land and ocean.

Key publication: Christensen, V., J. Buszowski, R. Forrest, F. Gao, C. Hoover, **J. Hui**, S. Lai, J. Steenbeek, W. Walters and C.J. Walters. 2007. All new Ecopath with Ecosim 6. PICES 16th Annual Meeting, Victoria BC, October 26-November 5, 2007, S3-4136 (poster).

Jennifer Jacquet, Post-doctoral Research Fellow; member since 2005.

Jennifer Jacquet completed, in 2009, a Ph.D. focused on seafood security in developing, and aspects of the seafood market in developed countries. She and other *Sea Around Us* members have published on issues related to seafood mislabeling, renaming, awareness campaigns, subsidies, and small-scale fisheries. She also helps with communication of results and media outreach for the project.

Key publication: **Jacquet, J.** and D. Pauly. 2007. The rise of consumer awareness campaigns in an era of collapsing fisheries. *Marine Policy* 31: 308-313.

Sherman Lai, Lead Programmer/Project Coordinator; member since 2003.

Sherman is a computer scientist who serves as coordinator for the Lenfest Ocean Futures Project, which develops software and methodology for a series of high-profile workshops, where high-level participants can cooperate to seek sustainable solutions to fisheries issues and their ecosystem impacts. Sherman also works with Villy Christensen on developing a new generation of the 'Ecopath with Ecosim' software, and he serves as advisor for many of our web-based activities.

Key publication: Kitchingman, A. and **S. Lai.** 2004. Inference on Potential Seamount Locations from Mid-Resolution Bathymetric Data. *In*: Morato, T. and Pauly, D (eds). Seamounts: Biodiversity and Fisheries. Fisheries Centre Research Reports. 12(5) p.7-12.

Vicky W.Y. Lam, PhD student since 2008; Research Assistant (GIS) since 2004.

Vicky was formerly a Geographic Information System (GIS) Specialist in the *Sea Around Us*. She provided support to the project, particularly for predicting and analysing commercial fish distributions, and mapping spatial information of various types of data. She developed a preliminary GIS based model to predict the dispersion of pollutants on a global scale. She also involved in the project for predicting the shift of distribution of commercial fish species under different climate change scenarios.

Vicky works as a PhD student under the supervision of R. Sumaila on the effect of climate change and energy price change on the economics of major commercial marine fisheries in the world

Key publication: **Lam, V.W.Y.**, W.W.L. Cheung, C. Close, D. Pauly. 2008. Modelling seasonal distributions of pelagic marine fishes and squids. p. 51-62. *In*: W.W.L. Cheung, D. Pauly, V.W.Y. Lam (eds). Modelling Present and Climate-shifted Distributions of Marine Fishes and Invertebrates. Fisheries Centre Research Report 16(3).

Ashley McCrea Strub, Post-doctoral Research Fellow since 2009.

Ashley, who joined the *Sea Round Us* from the University of Miami, is developing a framework for the evaluation of large vs. small marine protected areas (including those to be included in the Pew Environment Group's 'Legacy Project'), both with regards to protecting biodiversity and enhancing fisheries catches.

Gordon Munro, Professor of Economics (Emeritus). Throughout the existence of the *Sea Around Us*, Gordon worked closely with R. Sumaila on fisheries economic issues.

Key publication: **Munro, G.** and U.R. Sumaila. 2002. The impact of subsidies upon fisheries management and sustainability: The case of the North Atlantic. *Fish and Fisheries* 3:233-290.

Grace Ong, Administrative Coordinator; member since 2002.

Grace oversees the administration of logistical and financial aspects of the project, including preparing financial reports and budget proposals, coordinating the principal investigator's schedule and travels, and otherwise supporting project activities.

Grace Pablico, Research Assistant (database) since 2009.

Grace assists the leader of the *Sea Around Us* unit which maps fisheries catches, Dr Reg Watson, in meeting deadlines and delivering products.

Maria Lourdes 'Deng' Palomares, Senior Research Fellow; member since 2001.

Deng handles most biodiversity-related aspects of *Sea Around Us*, including its exchange of data with FishBase (www.fishbase.org), and represents the project in the international FishBase Consortium. Since 2005, she is also SeaLifeBase project coordinator (see www.sealifebase.org), a FishBase-like information system on all non-fish marine organisms, which contributes data to the *Sea Around Us*.

Key Publication: **Palomares, M.L.D.** and D. Pauly. 2009. The growth of jellyfishes. *Hydrobiologia* 616(1): 11-21.

Daniel Pauly, Principal Investigator since 1999.

Daniel wrote the initial proposal for the *Sea Around Us* Project in 1998. As its Principal Investigator, he initiates and/or actively participates in many of the publications of the Project and also acts as its main spokesperson with the media, funders, and through his public lectures on five continents.

Key publication: **Pauly, D.** 2007. The *Sea Around Us* Project: Documenting and Communicating Global Fisheries Impacts on Marine Ecosystems. *AMBIO: a Journal of the Human Environment* 34(4): 290-295.

Michelle Paleczny, MSc student since 2008.

Michelle's research, which continues that of Vasiliki Karpouzi, is on global seabird population abundance (351 species) and food consumption since 1950, and how they are being impacted by fisheries.

Lo Persson, Research Assistant since 2008.

Lo works on catch reconstructions, currently on marine catches of Somalia, and she reconstructed Sweden's catches in the Baltic Sea.

Chiara Piroddi

Msc student, 2005-2008; Research Assistant since 2009.

Chiara completed her M.Sc. under the supervision of Villy Christensen on an ecosystem-based approach to study dolphins in the Mediterranean. She is now constructing a database on global abundance and distribution of mesopelagic fishes, which are assumed to contribute half of the fish biomass in the oceans.

Peter Rossing, Research Assistant since 2009.

Peter undertook the day-to-day coordination of the catch reconstruction for the Baltic Sea countries, a collaboration with the Swedish *Baltic Sea 2020* Foundation in Stockholm. He also assists in other catch reconstruction related tasks in the *Sea Around Us*.

Key publication: **Rossing, P.,** S. Booth and D. Zeller. 2010. Total marine fisheries extractions by country in the Baltic Sea: 1950-present, 263 p.

Jeroen Steenbeek, Programmer since 2005.

Jeroen was heavily involved in programming the latest version (6.0) of Ecopath with Ecosim.

Key publication: Christensen, V., Z. Ferdaña and **J. Steenbeek**. 2009. Spatial optimization of protected area placement incorporating ecological, social and economical criteria. *Ecological Modelling* 220 p. 2583-2593.

U. Rashid Sumaila, Associate Professor; member since 1999.

In addition to being Director of the Fisheries Centre since late 2008 and head of the Fisheries Economics Research Unit at the UBC Fisheries Centre (www.feru.org), Rashid is the *Sea Around Us* Project's lead economist. He specializes in bioeconomics, marine ecosystem valuation and the analysis of global issues such as fisheries subsidies, IUU (Illegal, Unreported and Unregulated) fishing and the economics of high- and deep-seas fisheries.

Key Publication: **Sumaila, U.R.**, D. Marsden, R. Watson and D. Pauly. 2007. Global ex-vessel fish price database: construction and applications Journal of Bioeconomics 9:39-51.

Wilf Swartz, PhD student; Membership: 2000, 2002-2004, 2007 to present.

Wilf Swartz first joined the Project in 2000 as undergraduate research assistance, working with Dr Watson on the development of the catch database. From 2002 to 2004, he rejoined the Project as M.Sc. student with Dr Pauly during which he expanded the fishing agreement database in addition to his research involving the fish acquisition strategies of Japan. He returned to the Project in 2007 and has primarily focused on developing seafood trade and ex-vessel price databases.

Key publication: **Swartz, W.** and D. Pauly. 2008. Who's Eating all the Fish? The Food Security Rationale for Culling Cetaceans. Humane Society of the United States. Washington D.C.

Dawit Tesfamichael, PhD student since 2002.

Dawit is reconstructing fisheries historic fish catches in the countries bordering the Red Sea, analyzing the dynamics of its small-scale fisheries, and modeling the Red Sea Large Marine Ecosystem.

Key publication: **Tesfamichael, D.** and T.J. Pitcher. 2007. Estimating the unreported catch of Eritrean Red Sea Fisheries. *African Journal of Marine Science* 29(1) 55-63.

Ar'ash Tavakolie, Senior .NET Developer since 2008.

Ar'ash designs and maintains the *Sea Around Us* suite of web applications and the related databases. Besides updating and redesigning the project's website, he is currently working on 'SwordFish (SF)', which will replace the core components of old legacy code with a multi-tiered architecture. He is developing SF to make the projects web/databases applications more agile, extensible and also lower the maintenance costs.

Pablo Trujillo, Msc student, 2001-2007; Research Assistant since 2009.

Pablo completed his MSc under the supervision of Daniel Pauly looking at sustainability of marine aquaculture. After working at the University of Victoria, Canada, he is now back with the *Sea Around Us* Project to work in a project with MarViva (Costa Rica) that will undertake catch reconstructions for Central American countries.

Key publication: **Trujillo, P.** 2008. Using a mariculture sustainability index to rank countries' performance. p. 28-56 *In:* J. Alder and D. Pauly (eds). A comparative assessment of biodiversity, fisheries and aquaculture in 53 countries' exclusive economic zones. Fisheries Centre Research Reports 16(7).

Laura Tremblay Boyer, Msc student since 2007.

Laura is completing a thesis on biomass change in the world ocean since 1950 using the Ecopath model developed under the leadership of Dr Didier Gascuel, a collaborator of the *Sea Around Us*.

Key publication: **Tremblay-Boyer, L.**, D. Gascuel and D. Pauly. 2009. Estimation et cartographie de l'impact de la pêche sur les biomasses marines à l'échelle mondiale, de 1950 à 2004. 9ième Forum Halieumétrie -Les indicateurs en halieutique : pertinence, précision et robustesse", Brest, Juin 2009.

Colette Wabnitz, PhD student since 2004.

Colette's dissertation seeks to derive an estimate of seagrass coverage at the scale of the wider Caribbean region and to understand the role of green sea turtles within these ecosystems. Along the way, she has also contributed to many other *Sea Around Us* projects and publications.

Key publication: **Wabnitz, C.**, S. Andréfouët, and F.E. Muller-Karger. 2009. Measuring progress toward global marine conservation targets. *Frontiers in Ecology and the Environment* doi:10.1890/080109.

Reg Watson, Senior Research Fellow; member since 1999.

Reg works as a fisheries data detective and analyst to map global fisheries catch and effort allowing the *Sea Around Us* to investigate interactions with marine ecosystems. He collaborates in global studies of marine biodiversity, the economics of fishing, and impacts on birds and mammals. He is interested in developing better ways to assess the health of exploited marine systems, the impacts of climate change, and the social consequences of mismanagement.

Key publication: **Watson, R.** and D. Pauly. 2001. Systematic distortions in world fisheries catch trends. *Nature* 414: 534-536.

Dirk Zeller, Senior Research Fellow/Project Manager; member since 1999.

Dirk directs the *Sea Around Us* catch data reconstructions, including international collaborations and in-house projects. He also has the strategic lead in all aspects of the Project's web-presence. Dirk also works on global marine pollution modeling, engages in ocean governance and fisheries policy research, and collaborates with the Fisheries Economics Research Unit on issues in resource economics. As Project Manager, he also directs the day-to-day activities of the Project, and liaises with its Principal Investigator

Key publication: **Zeller, D.**, S. Booth, G. Davis and D. Pauly. 2007. Re-estimation of small-scale fisheries catches for U.S. flag island areas in the Western Pacific: The last 50 years. *Fisheries Bulletin* 105: 266-277.

Former Team Members[1]

Jackie Alder, Senior Research Fellow, 1999-2007.

Jackie, now Head of the Division of Environmental Policy Implementation, UNEP, Nairobi, led numerous policy-related activities of the *Sea Around Us*, notably the Forage Fish Project, scenario work, West African access, estuaries, aquaculture database, and our comparative evaluation of countries' management of their EEZs. She also was our main contact person with outside initiatives, e.g., such as the OECD Environmental Outlook and the Millennium Ecosystem Assessment. In 2006/2007, she was also tasked with project management and outreach.

Key publication: **Alder, J.**, B. Campbell, V. Karpouzi, K. Kaschner and D. Pauly. 2008. Forage fish: from Ecosystems to Markets. *Annual Reviews in Environment and Resources* 33: 153-166.

Line Bang Christensen, MSc student, 2007-2009.

Using advance modeling techniques and historical datasets, Line reconstructed historical abundances of all marine mammals at a global scale. Line is now studying Law.

Key publication: **Christensen, L.B.** 2006. *Marine Mammal Populations: Reconstructing historical abundances at the global scale.* Fisheries Centre Research Report, 14(9).

[1] This is a partial list, omitting some technical and support staff, students and consultants. For a full roster see our five year report (*Sea Around Us.* 2005. The *Sea Around Us* Project: a Five-Year Retrospective. Fisheries Centre, University of British Columbia, 56 p.) and Annex 1, p. 249-254 *In:* Zeller, D., R. Watson and D. Pauly (Editors). 2001. *Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Data Sets*. Fisheries Centre Research Reports 9(3), which has a full list for the first 2 years of the Project.

Jordan Beblow, Research Assistant, 2003-2008.

Jordan worked mainly on assembling a global database of biomass trends to support the synthesis work of V. Christensen.

Key publication: Alder, J., S. Guénette, **J. Beblow**, W. Cheung and V. Christensen. 2007. Ecosystem-based Global Fishing Policy Scenarios. Fisheries Centre Research Report, 15(7).

Rosalie Casisson, IT Support, 2001-2007.

Rosalie looked after the hardware and software that *Sea Around Us* and Fisheries Centre members used.

Chris Close, GIS analyst, 2005-2008.

Chris provided GIS services to fulfill the needs of the project, including mapping catches and other data, and met the mapping needs for the *Sea Around Us* website.

Key publication: **Close, C.**, W.W.L. Cheung, S. Hodgson, V. Lam, R. Watson and D. Pauly. 2006. Distribution ranges of commercial fishes and invertebrates, p. 27-37 *In*: M.L.D. Palomares, K.I. Stergiou and D. Pauly (eds). *Fishes in Databases and Ecosystems.* Fisheries Centre Research Reports 14(4).

Robyn Forrest, Newsletter Editor, 2002 -2008.

Key contributions: Robyn was a PhD student at the Fisheries Centre, working under the supervision of Tony Pitcher, and edited and disseminated the bimonthly *Sea Around Us* newsletter. Robyn now holds a position with Fisheries and Oceans Canada (DFO).

Katia Freire, PhD student, 2000-2005.

Katia studied Brazilian fish and fisheries, and continues to collaborate with D. Pauly, her

former advisor. She is now an Assistant Professor at the Universidade Federal do Rio Grande do Norte in Brazil.

Key publication: **Freire, K.M.F.**, V. Christensen and D. Pauly. 2007. Assessing fishing policies for northeastern Brazil. *Pan-American Journal of Aquatic Sciences* 2: 113-130.

Ahmed Gelchu, PhD student, 2001-2007.

Ahmed, now with BC Hydro, completed a thesis on the spatial distribution of the world's port-based fishing fleet from 1970-1995, the first evaluation of this kind.

Key publication: **Gelchu, A.** and D. Pauly. 2007. *Growth and distribution of port-based global fishing effort within countries' EEZs from 1970 to 1995.* Fisheries Centre Research Reports 15(4).

Sylvie Guénette, Post-Doctoral Fellow, 1999-2003; Research Associate, 2004-2008.

Sylvie applied her modeling expertise to the construction of ecosystem models in various parts of the Atlantic, and edited a comprehensive volume documenting an early phase of the project's work. She has since participated in the development of the EcoOcean model, used for UNEP's GEO4 studies, and other global assessments. She is now a Research Scientist with DFO, New Brunswick, NS.

Key publication: **Guénette, S.**, V. Christensen and D. Pauly. 2008. Trophic modelling of the Peruvian upwelling ecosystem: towards reconciliation of multiple datasets. *Progress in Oceanography* 79: 326-335.

Nigel Haggan, Project Manager, 1999-2004.

Nigel was our first project manager, and as such, he helped set up the *Sea Around Us*.

Sheila Heymans, Research Associate, 2003-2006.

Sheila concentrated on ecosystem model construction of marine and estuarine systems and for the *Sea Around Us*, she constructed ecosystem models of the Gulf of Maine and the Sierra Leonean Shelf.

Key publication: **Heymans, J.J.**, U.R. Sumaila and V. Christensen. 2009. Policy options for the northern Benguela ecosystem using a multi-species, multi-fleet model. *Progress in Oceanography* 83:417-425.

Vasiliki Karpouzi, MSc student, 2001-2005; Research Assistant, 2005-2007.

Vasiliki mapped forage distribution, food consumption, and resource overlap between global fisheries and the world's 351 species of seabirds. She used seabird diet composition and estimated population sizes since 1950 from a database she created and populated. This work is continued by Michelle Paleczny (see above).

Key publication: **Karpouzi, V.S.**, R. Watson and D. Pauly. 2007. Modelling and mapping resource overlap between fisheries and seabirds on a global scale: a preliminary assessment. *Marine Ecology Progress Series* 343: 87-99.

Kristin Kaschner, PhD student, 1999-2005.

Kristin's PhD research conducted under the supervision of Drs. D. Pauly and A. Trites, focused on the assessment of global resource overlap between marine mammals and fisheries to assess the extent of potential competition between the two. The spatial model underlying this work also forms the basis for AquaMaps (www.aquamaps.org), a project aiming to provide standardized range maps for eventually all marine organisms. As a research affiliate at the University of Freiburg, Germany, she continues to work on the application and development of large-scale habitat suitability modelling approaches to investigate potential impacts of anthropogenic activities, including climate change, fisheries or noise pollution, on marine mammals and other marine organisms.

Key publication: **Kaschner, K.**, R. Watson, A.W. Trites and D. Pauly. 2006. Mapping world-wide distribution of marine mammal species using a Relative Environmental Suitability (RES) model. *Marine Ecology Progress Series* 316: 285-310.

Ahmed Khan, MSc student, 2004-2007.

Ahmed, a student of U.R. Sumaila, devoted his master's thesis to the subsidies, which the governments of maritime countries give to their fisheries.

Key publication: **Khan, A.**, U.R. Sumaila, R. Watson, G. Munro, and D. Pauly. 2006. The nature and magnitude of global non-fuel fisheries subsidies, p. 5-36. *In:* Sumaila, U.R. and D. Pauly (eds). *Catching more bait: a bottom-up re-estimation of global fisheries subsidies.* Fisheries Centre Research Reports 14(6).

Adrian Kitchingman, Research Assistant, 2002-2005.

Presently a programmer and data analyst at the Arthur Rylah Institute in Heidelberg, Victoria, Australia, Adrian played a key role in the development, management, including updates, and documentation of the *Sea Around Us'* spatial catch allocation model and the pre-processing of its numerous underlying datasets.

Key publication: **Kitchingman, A.**, S. Lai, T. Morato and D. Pauly. 2007. How many seamounts are there and where are they located? Chapter 2, p. 26-40 *In*: T.J. Pitcher, T. Morato, P. Hart, M. Clark, N. Haggan and R. Santo (eds). *Seamounts: Ecology Fisheries and Conservation.* Blackwell Fish and Aquatic Resources Series 12, Oxford, U.K.

Elizabeth Mohammed, PhD student, 1999-2007.

Elizabeth worked on reconstructing the real marine catch of Caribbean countries but eventually withdrew from her PhD program.

Key publication: **Mohammed, E.** 2003. Reconstructing fisheries catches and fishing effort for the southeastern Caribbean (1940- 2001): General methodology. p. 11- 20 *In:* D. Zeller D., S. Booth, E. Mohammed and D. Pauly (eds). *From Mexico to Brazil: Central Atlantic fisheries catch trends and ecosystem models*. Fisheries Centre Research Reports 11(6).

Suzanne Mondoux, **A**dministrative Assistant, 2005-2008.

Suzanne was an assistant to Dr Pauly while completing a MSc thesis.

Key publication: **Mondoux, S.**, T.J. Pitcher and D. 2008. Ranking maritime countries by the sustainability of their fisheries. p. 13-29. *In:* J. Alder, J. and D. Pauly (eds). A comparative assessment of biodiversity, fisheries and aquaculture in 53 countries' exclusive economic zones. Fisheries Centre Research Reports 16(7).

Telmo Morato, PhD student, 2002-2006.

Telmo investigated the functioning of seamount ecosystems and the impact of fishing in such ecosystems. He has also demonstrated with D. Pauly that global landings of marine fishes have shifted to deeper water species over the last 50 years. Telmo is now a project collaborator, based at the University of the Azores, Portugal.

Key publication: **Morato, T.**, R. Watson, T.J. Pitcher and D. Pauly .2006. Fishing down the deep. *Fish and Fisheries* 7(1): 24-34.

Lynn Morissette, PhD student, 2001-2007.

Lynn examined the complexity, cost, and quality of ecosystem (Ecopath) models and their impact on resilience of the functional groups therein, with some emphasis on marine mammals in the Gulf of St. Lawrence.

Key publication: Gerber, L., **L. Morissette**, K. Kaschner and D. Pauly. 2009. Should whales be culled to increase fishery yields? *Science* 323: 880-881.

Tony Pitcher, Professor, member from 1999-2003; now-occasional collaborator.

A Professor of fisheries and the former Director of the Fisheries Centre (FC), Tony was instrumental in helping set up the *Sea Around Us* within the FC, and chaired its Steering Committee that it had in its first 2

years. Dr Pitcher's work for the project (since Oct. 2004 on a consulting basis) focuses on Illegal, Unreported and Unregulated (IUU) fisheries.

Key publication: **Pitcher, T.J.**, R. Watson, R. Forrest, H. Valtýsson and S. Guénette. 2002. Estimating Illegal and Unreported Catches From Marine Ecosystems: A Basis For Change. *Fish and Fisheries* 3: 317-339.

Amy Poon, MSc student, 1999-2005.

Amy who now works as an outreach person for the Vancouver Aquarium, completed her thesis with D. Pauly on ghost fishing by lost traps in crab fisheries.

Melanie Power , Newsletter Editor, 1999 to 2002.

Melanie was a PhD student of Dr Pitcher, and edited the *Sea Around Us* Newsletter, following a design provided by Ms Nancy Baron.

David Preikshot, PhD student, 2000-2007.

Following an MSc under the supervision of Dr Pauly, David completed a PhD under the joint supervision of Dr Pauly and Dr Christensen, on ecosystem modeling with emphasis on the influence on geographic scale on trophic dynamics.

Key publication: **Preikshot, D.** 2001. Observation and inspection data: determining catch and bycatch by foreign fisheries on the grand Bank outside the Canadian EEZ. p. 240-248 *In:* D. Zeller, R. Watson and D. Pauly (eds). *Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Data Sets*. Fisheries Centre Research Reports 9(3).

Yvette Rizzo, PhD student, 2000-2007.

Yvette, presently on an extended maternity leave in Malta, her home country, worked with her advisor D. Pauly, on Mediterranean fisheries.

Key publication: **Rizzo, Y.** and D. Zeller. 2007. Country disaggregation of catches of former Yugoslavia, p. 149-159. *In:* D. Zeller and D. Pauly (eds). *Reconstruction of marine fisheries catches for key countries and regions (1950-2005).* Fisheries Centre Research Reports 15(2).

Lore Ruttan, Postdoctoral Fellow, 1999-2000.

Lore worked on the competitive relationships between small- and large scale fisheries.

Key publication: **Ruttan, L.M.**, F.C. Gayanilo Jr. U.R. Sumaila and D. Pauly. 2000. Small- versus large-scale fisheries: a multi-species multi-fleet model for evaluating their interactions and potential benefits. p. 64-78. *In:* D. Pauly and T.J. Pitcher (eds). *Methods for Evaluating the Impacts of Fisheries on North Atlantic Ecosystems.* Fisheries Centre Research Reports 8(2).

Fred Valdez, Web Programmer, 2000-2007.

Fred developed and maintained the *Sea Around Us* website from 2001 to 2007. He designed the initial database for the project website, and developed our first Internet-based GIS mapping system.

Laura Vidal-Hernandez, MSc student, 1999-2000.

Laura developed a method for aggregating ecosystem (Ecopath) models into a combined model for a larger area, and applied it to the Gulf of Mexico.

Key publication: **Vidal-Hernandez, L.** and D. Pauly. 2004. Integration of subsystem models as a tool toward describing feeding interactions and fisheries impacts in a Large Marine Ecosystem, the Gulf of Mexico. *Ocean and Coastal Management* 47: 709-725.

Louisa Wood, PhD student, 2003-2007.

Based on a preliminary database from the World Conservation data Center (WCMC), Louisa, as part of her PhD thesis under Dr Pauly,

created a database with the size, location and other information on over 4,000 individual marine protected areas (MPAs), now available via our website, and which allowed multiple insights into the architecture and growth of this global 'network' of MPAs.

Key publication: **Wood, L.**, L. Fish, J. Laughren and D. Pauly. 2008. Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx* 42(3): 340-351.

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Ken Sherman of NOAA, Daniel Pauly, and Rashid Sumaila discussing Large Marine Ecosystems in the Fisheries Centre's Immersion Lab.

Digital Globe, used to project and show various ocean states.

Sherman Lai and Villy Christensen - at work or not?

Project Collaborators

The *Sea Around Us* had, in its ten years of existence, a vast number of collaborators of various kinds, ranging from short-term consultants we hired, via former team members with whom we continued collaborating, to large groups based at other institutions and working with us on a range of issues.

The bulk of these collaborations led to publications, and thus our peer-reviewed articles (p. 43-52) or other reports (p. 53-54 and see our website) account for them. However, we would be remiss if we did not mention explicitly the excellent cooperation we had with Dr Rainer Froese and the other members of the FishBase Consortium, whose main product – FishBase (see www.fishbase.org) – is used extensively as input to most of the maps, ecosystem models and other syntheses of the *Sea Around Us*.

Other groups have also been, and continue to be, important partners, notably Dr Rob Alkemade and the Netherlands' Environmental Assessment Agency, the US National Oceanographic and Atmospheric Agency, with whom we executed various projects, notably with Dr Ken Sherman on Large Marine Ecosystems, and the Department of Bioscience at Princeton University, led by Dr Jorge Sarmiento, our main partner for our climate change work.

Finally, we have frequent collaborators in the environment and advocacy community, notably the Pew Environment Group, which is natural since the bulk of our funding originate with the Pew Charitable Trusts, but also World Wildlife Fund (WWF), which has supported several of our smaller projects, Oceana, with whom we carried our work on subsides all the way to the World Trade Organization in Geneva, and Dr Enric Sala and *National Geographic*, with whom we are comparing the 'seafoodprint' of the countries of the world.

In addition to our publications, our website features collaborators and collaborations, and the reader is referred to www.searoundus.org for further details.

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LIST OF ACRONYMS

CBD	Convention on Biological Diversity
CPUE	Catch per Unit of Effort
EEZ	Exclusive Economic Zone
ICES	International Council for the Exploration of the Sea
FAO	Food and Agriculture Organization of the United Nations
MTI	Marine Trophic Index
NAFO	Northwest Atlantic Fisheries Organization
NGO	Non-Government Organization
NOAA	United States National Oceanic and Atmospheric Administration
OECD	Organization for Economic Co-operation and Development
UNCLOS	United Nations Convention on the Law of the Sea
WTO	World Trade Organization

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