

# Sea Around Us

## Four years of the *Sea Around Us* Project

by Daniel Pauly  
Principal Investigator

The *Sea Around Us* Project (SAUP), named after Rachel Carson's famous book (pictured), formally started in July 1999, with the goal of investigating and reporting on the impact of fisheries on marine ecosystems. The SAUP radically differed from other projects that may have appeared to have similar goals in that it was global in scope, i.e., it was designed to assess the impact of fisheries on *all* of the world's ocean. This required the development of a completely new methodology for representing fisheries, and for presenting their development and impacts at the scale of oceanic basins, or even globally.

This methodology, largely developed by SAUP team members Reg Watson and Villy Christensen, is now mature and has enabled us to represent, through maps,



processes usually represented as trend lines on bivariate graphs. It is probably one of the major reasons for the visibility of SAUP results in various media, ranging from scientific journals such as *Science* and *Nature*, to magazines (e.g., *Scientific American*), newspapers (including recently the cover of the 'Science Times' section of the *New York Times*), TV interviews and documentaries and public lectures and briefings (including on Washington's Capitol Hill, and Brussels' European Commission).

Our focus in the first two years of the project was the North Atlantic, mainly because the abundance of field data, resulting from a century of tracking fisheries, made it easier to test the methodology against traditional approaches, but also because of the critical

audience provided by the many marine biologists and fisheries scientists in the government and private laboratories in countries surrounding the North Atlantic.

We survived this scrutiny, and indeed managed to turn the table on potential critics by marshalling evidence in a book titled *In a Perfect Ocean*, pointing at a massive decline of the North Atlantic resources, attributable to a massive failure of the regulatory agencies in the countries bordering the North Atlantic. Ransom A. Myers and Boris Worm, in a widely noted article in *Nature* (Vol. 423, pp. 280-283) have since shown that we probably underestimated the decline of large fish in the North Atlantic - we did not mind being wrong that way.

The third year of the SAUP essentially consisted of extending the methodology developed for the North Atlantic to the rest of that ocean, i.e., the tropical Western

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Atlantic, from the Gulf of Mexico through the Caribbean to Brazil, the west coast of the African continent, and the South Atlantic all the way to Antarctica.

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In the Western Central Atlantic, however, the usually deplorable state of fisheries statistics required us to devote considerable energy to assemble, in collaboration with scientists in the various countries, credible catch time series, a process led by Dirk Zeller, following his completion of similar work in the North Atlantic. As well, a large amount of marine biological data was synthesized in the form of mass-balance food web (Ecopath) models for different ecosystems in the region, notably the Gulf of Mexico.

West African fisheries statistics are usually in better shape, and there, we were able to skip the data reconstruction phase. Rather, emphasis could be given to synthesis, here achieved, as for the North

Coverage of the Southern Atlantic by the SAUP included analysis of the Namibian fisheries using various approaches (time series of ecosystem indicators documenting the 'fishing down marine food webs' effect and

ecosystem modeling), and modeling of the Southern Atlantic and Antarctic systems, including the ecosystems around the Falkland Islands, the Weddell Sea and, via Deng Palomares in collaboration with a French group, the Kerguelen Islands. While we should soon be able to present a regional (South Atlantic) synthesis of these results, they have already found use in some global analyses, as they



Sea Around Us team members. Top (L-R): Cindy Young, Vasiliki Karpouzi, Shawn Booth, Deng Palomares, Catriona Day, Adrian Kitchingman, Daniel Pauly, Reg Watson, Sandra Pauly, Katia Freire and Juarez Rodrigues. Bottom (L-R): Villy Christensen, Dirk Zeller, Jackie Alder and Deng Palomares.

Atlantic, by integrating Ecopath models, many constructed by SAUP staff in collaboration with West African colleagues, into a single spatial representation. The resulting maps, documenting strong declines of fish biomass along the entire coast of North West Africa, had a huge media impact following their initial presentation at an international symposium initiated by the SAUP, and held in Dakar, Senegal, in June 2002.

cover the extreme, southern end of the global expansion of fisheries that started after World War II and which ended when large trawler fleets began routine, if often semi-legal, operations around the Antarctic Continent.

The fourth year of the SAUP emphasized the north Pacific, though global analysis by the project staff as a whole became

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The *Sea Around Us* website may be found at [saup.fisheries.ubc.ca](http://saup.fisheries.ubc.ca) and contains up-to-date information on the project.

**T**he *Sea Around Us* project is a Fisheries Centre partnership with the Pew Charitable Trusts of Philadelphia, USA. The Trusts support nonprofit activities in the areas of culture, education, the environment, health and human services, public policy and religion. Based in Philadelphia, the Trusts make strategic investments to help organisations and citizens develop practical solutions to difficult problems. In 2000, with approximately \$4.8 billion in assets, the Trusts committed over \$235 million to 302 nonprofit organisations.

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more common. Emphasis in the North Pacific is devoted to separating strong environmental signals, 'regime shifts', from fisheries impacts on ecosystems. For this, the SAUP can rely on a vast trove of ecosystem models and analysis - most conducted with Ecopath with Ecosim which is now widely used by researchers in the Pacific Northwest. To achieve some regional balance, construction of models in the Eastern North Pacific was also encouraged notably to cover the Sea of Okhotsk and other areas along the coast of northeast Asia. All of these models explicitly account for interactions between marine mammals and fisheries which are extremely important in the North Pacific and which will be emphasized in forthcoming publications.

The global analyses conducted in parallel to this regional work covered the fuel consumption by the world's fishing fleets (therein extending globally a previous analysis which covered the North Atlantic alone), and the creation of a global database of ex-vessel prices of fish, a product that strangely enough did not exist previously, and which will allow for the first time a correct estimation of the 'value' of fisheries so far overestimated by the use of wholesale fish prices. We expect the publications emanating from these global studies to reframe the context within which fisheries have been discussed so far, just as our previous analyses of global catch trends have.

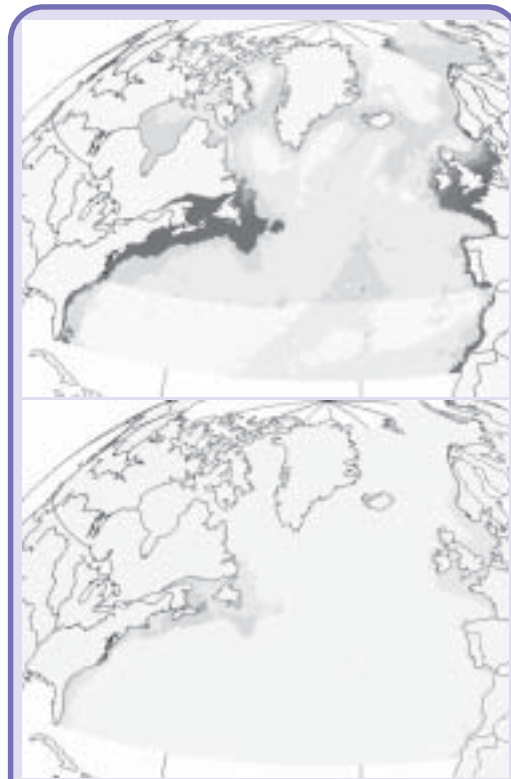
The SAUP project is now entering its 5<sup>th</sup> year. Herein, emphasis will be given to small-scale fisheries and their catches,

notably in countries of the tropical Indo-Pacific. Given the coastal nature of these tropical small-scale fisheries, due consideration will have to be given to habitat-dependence and impact of these fisheries, notably on mangrove, seagrasses, coral reefs, etc., which are now integrated into

MA's Scenario Working Group. Indeed, some of our results on this are anticipated in a contribution to appear this fall in *Science* presenting various scenarios for the development of marine fisheries to the year 2050.

The above account of the SAUP activities is rather dry - it fails to convey the excitement of discovering new ways of presenting trends in global fisheries, the excitement of audiences and readers in first seeing those patterns, the excitement of various media outlets in recounting the main conclusion drawn from our analyses, etc. However, readers may perhaps partake in this by visiting our soon to be improved website ([www.saup.fisheries.ubc.ca](http://www.saup.fisheries.ubc.ca)) where our publications are presented along with a thorough documentation of the media coverage by newspapers,

... the excitement of discovering new ways of presenting trends in global fisheries, the excitement of audiences and readers in first seeing those patterns ...



Maps created by Villy Christensen and Adrian Kitchingman, illustrating the decline in biomass of high trophic-level fishes over the past 100 years. Top: estimated biomass distributions of top predators in 1900. Bottom: estimated biomass distributions for the same in 1999, indicating a decline of more than two-thirds. Darker shaded areas indicate greater biomass. For a full-colour, animated version of these maps, visit [www.saup.fisheries.ubc.ca/trends.htm](http://www.saup.fisheries.ubc.ca/trends.htm). See also Christensen et al. 2003. Hundred-year decline of North Atlantic predatory fishes. *Fish and Fisheries* 4, 1-24.

the SAUP global database. This work will also feed into the Millennium Ecosystem Assessment (MA) within which this author has responsibility within the 'Marine System' chapter and in which Jackie Alder plays a key role by connecting our work to the MA's coastal chapter and the

magazines, TV interviews, etc. Readers may also be interested to view our Web Products, also available on our website, which include interactive maps of global catches and national fisheries, as well as links to a fully interactive site about our 2002 symposium in Dakar, Senegal.





# Salmon farming in Chile

by Jim Fulton

*Companies can write off 17% of costs at all levels... [and] receive a 49% tax reduction if they establish businesses in the Chilean Antarctic region...*

*Earlier this year, Jim Fulton, Executive Director of the David Suzuki Foundation, travelled to southern Chile and conducted a series of interviews with representatives of Chile's billion-dollar salmon farming industry workers, conservation groups and the Chilean government. His findings raise serious concerns about the impact of salmon aquaculture on Chilean coastal marine ecosystems and communities and add an important and timely contribution to the global debate surrounding this issue. His findings and conclusions are exclusively reported below.*

Chile's large-scale salmon aquaculture industry was established by Fundación Chile, a government-funded institution formed in 1973, following the military coup by General Pinochet to replace the duly elected President Salvador Allende. Prior to 1973, chinook and other species of salmon had been introduced into several river systems but all had died out. Today, the role of the Fundación is to conduct basic research and testing of new aquaculture methodologies and sell the operations to the private sector. There are currently about 600 licensed salmon and trout marine sites in Chile and 150 licensed lake sites. Production is 30% rainbow trout, 30% coho salmon (333,000 tonnes of rainbow trout and coho combined) and 40% Atlantic salmon (219,000 tonnes). As well as salmon, the Fundación is presently developing methodologies for farming 12 new species including red

abalone, flounders, hake, sturgeon and Patagonian toothfish.

Investment in the industry is actively encouraged. Companies can write off 17% of costs at all levels if they set up in the two regions south of Puerto Montt. Companies also receive a 49% tax reduction if they establish businesses in the Chilean Antarctic region and this has led to a massive southern expansion of fish-farming, despite the extra transport costs. The Norwegian government also gives its national companies subsidies to operate in Chile.

Globally, annual production of farmed fish is around 45 million tonnes. Chile produces the world's second-highest yield of farmed salmon (behind Norway), but is expected to become number one by the end of 2003. Of the 45 million tonnes of fish farmed globally, 85% are freshwater species, mainly herbivorous carp and tilapias. While the percentage of carnivorous marine species is smaller, the effects are thought to be significant, largely because the production of carnivorous fish such as trout and salmon requires 5 kg of wild fish to produce every kilogram. Aquaculture currently consumes 70% of the global supply of fish oil and 34% of fish meal, with salmon and trout production alone using 54% of the world's fish oil! The world's largest fishmeal and fish oil producers are Peru and Chile, with huge fisheries for sardines, mackerel and anchovies

providing most of the fish oil used in Chilean aquaculture. There have been serious crashes in these fisheries, linked to overfishing and climatic events. For example, catches of the South American sardine (*Sardinops sagax*) crashed from 6.5 million tonnes in 1985 to a mere 60,000 tonnes in 2001. Expansion of the salmon farming industry into the Chilean Antarctic and interest in developing a Patagonian toothfish aquaculture industry has led to fears that aquaculture cartels (which control the production of the feed as well as owning the farms) will soon begin massive exploitation of krill in the Antarctic. Notwithstanding the expansion of krill fisheries, the ceiling on wild fish oil production is expected to be reached in 2005 or sooner. Aware of this and the heavily over-exploited state of pelagic fisheries, scientists working for two of Chile's major salmon-farming companies (*Marine Harvest* and *Nutreco*) have been experimenting with different levels of vegetable oil replacement in fish feed. Currently, most fish feeds contain around 10% vegetable oil and researchers are hopeful that this percentage can be increased in the future. Unfortunately, they have found serious "taste" resistance to fish fed on vegetable oils from Japanese consumers, who buy the majority of the coho salmon produced. Industry will therefore be returning farmed coho to feed containing 100% fish oil.

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I met with a team of scientists from Servicio Agrícola Ganadero. This government department controls all drugs coming into Chile for use on animals and registers all drugs and vaccines for fish. There are presently 98 products approved for fish, 89 pharmacological drugs and 9 vaccines. During 2001, the government of Chile moved to encourage fish farmers to use Chilean-made fish vaccines. At that time, over three million doses came from outside Chile and only 89,000 from Chile. Rather than use Chilean vaccines, however, fish farmers have shifted to putting more drugs directly into the feed as additives, which has become a serious problem. In addition, there are dozens of other "off-label" drugs used to deal with a vast array of bacteria, viruses and parasites such as sea-lice.

I raised the issue of sea-lice with several of my correspondents. Most government representatives I met were aware of potential problems but did not consider sea-lice a serious enough problem to warrant a shift to closed containment cages, despite a recent finding in Chile that, for fish up to 1 kg in weight, it is cheaper (per kilo of fish) to raise salmon in closed containment rather than open netcages. Scientists at Fundación Chile acknowledged that sea-lice can be found on nearshore stocks of schooling fishes but are of the opinion that Southeast Pacific sea-lice are smaller and less ferocious than those found in British Columbia. There have been no studies on rates of movement of sea-lice between wild and farmed stocks.

Regarding pollution, Fundación Chile representatives assured

me that fish farms are working together on developing methodologies for killing and processing the fish to reduce the amount of blood and offal going into the environment. Salmon heads, spine, tail and guts are being processed for fish meal (not salmon feed) and for human uses. Industry representatives could not, however, give me a satisfactory answer about the volume of waste that is turned into fish oil and feed. At an estimated 550,000 tonnes of trout and salmon produced, with 40% waste, we are talking several hundred thousand tonnes. Other forms of pollution include faeces and copper sulphate, which is still used in many farms for net-cleaning, even though its use is illegal. The magnitude and ecological impacts of pollution from open netcages are not being measured or investigated.

Escaped salmon and trout have become established in many rivers and streams and there is a great deal of concern about their impact on fragile coastal environments. As well, the farms themselves reduce the space available for local commercial and subsistence fishers and the fish stocks they depend upon. The problems created for artisanal fishers, for communities and for fish in the diet of southern Chileans is growing. Twenty-two percent of Chileans are now protein deficient and this is partly due to upward price pressure, but also due to the complete disappearance of some traditional species from the markets and the near-shore catch. The impacts of salmon farms and hatcheries in freshwater lakes have been horrific. A knowledgeable local guide took me to Puerto Varas on the largest lake in Chile. Of

the 17 resident species eaten by locals, 10 have been extirpated, due to the escape of salmon and trout into the lake and there is now only licensed "sport" fishing in the lake (for salmon and trout). Artisanal fishers at virtually every location near salmon farms complain of declining catches, which are affecting coastal communities with lost jobs. Officially, the problem is masked by endemic over-reporting of catches to keep up with quota re-allocations assigned by the government. As traditional species of fish disappear from the local markets, the number of Chileans at nutritional risk is expected to rise, especially since farmed species are prohibitively expensive in the markets. Even though the near-shore zone is "reserved" for artisanal fisheries (and all salmon farms are in this zone), the government's Environmental Commission continues to approve more licences. There are striking similarities here to the inherent conflict of interest seen in Canada, where the regulator (the federal Department of Fisheries and Oceans) acts as the promoter of salmon farming. No-one in government seems to actually act to protect, conserve and restore the wild fisheries! Few studies have been done to establish baseline estimates of abundance of marine mammals, birds, invertebrates or wild fish, despite a growing body of evidence of negative ecological impacts.

The social problems caused by the salmon farming industry extend to its workers. Union representatives and other concerned correspondents

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painted a worrying picture of the industry. Workers are paid US\$1 per hour (ten times less than their equivalents in Canada and Scotland) and many suffer from repetitive strain injury and what appear to be infections caused by antibiotic-resistant strains of the bacteria *Streptococcus iniae*, resulting from handling infected fish. Of the 24,000 member workforce, only 4200 are organized. Strike-action in 2001 against one of the major companies resulted in the firing of 57 workers and their black-listing from the industry. Following a recent OECD complaint filed in the Netherlands against another major salmon-farming company, two presidents of the salmon farm unions have “disappeared”. The whereabouts of one is now known but he will no longer assist with the enquiry and will no longer meet or talk. The whereabouts of the other is unknown. The disappearance of these two men has made the process of confirming what workers have reported to the union more difficult to verify for the international process – an issue already raised by the OECD. The union in southern Chile faces other problems: not only have two union presidents disappeared, it will soon lose its tiny office-space and the national representative will not assist unionized workers in their ongoing struggle against the industry cartel, in which salmon farms, processing plants and fish feed supply are all controlled by a handful of transnational companies. During my trip, I was struck several times by the impression that pressure tactics and criminal force are a big problem here. In recent months, the

offices of all non-governmental organizations working on environmental issues in Santiago have been burgled. There is a great degree of difficulty with engaging in transparent dialogue on these issues.

I met with a representative of the industry's science and public relations arm, INTESAL, but came away with the impression that it is little more than a well-funded creature of the salmon-farming cartel. They recognize that there are problems but will not commit to census work, testing for disease-transfer to the wild, consideration of impacts on marine mammals or anything else. Rather, INTESAL is seen as a way to get “information” into schools and communities. Despite these concerns, I did meet with several scientists and representatives of conservation organizations who were attempting to improve the state of research and monitoring of the salmon farming industry. One correspondent outlined his plan for an international salmon farm watch website, which would list everything from kill numbers of sea lions and birds to labour issues and criminal convictions of companies. Access to comparative data between salmon farming countries (such as Canada, Norway and Scotland) would be a great advantage and there is a real need for an independent science body to compare the impacts of salmon farms in a number of international jurisdictions. At present, the government regulatory body of the region (the 10<sup>th</sup> Region Environmental Commission) has no real idea of the impacts of salmon farming; no budget or staff for basic research; and is forced to rely on industry to “do the right thing”. There is also a

need to investigate the industrial cartel on prices, subsidies, taxation, national policies, exports and the legal rights of historic users of marine resources.

It is my view that a transition plan back to community-based sustainable fisheries, that includes conservation-based value-added integrated marine industries, is a matter of urgency for Chile. While Chile may soon be the largest producer of farmed salmon in the world there are many signs that this industry will collapse. Local communities and consumers must also be given access to factual information about the impacts of salmon-farming. A web-site that accurately reflects the impacts of the global salmon-farming industry must be established by the academic and non-government community and high-profile news stories in papers such as the New York Times must also be pursued.

Salmon farming is but one facet of the international cartel to privatize the near-shore coastlines and ocean-bottoms for everything from algae production to shellfish to fish. Given that the overwhelming bulk of the world's marine landings come from waters under national jurisdiction, this is a social, legal and international issue that needs immediate attention in Chile and in all coastal nations.

*Eds: Readers may be interested to contrast this article with The Economist's “The promise of a blue revolution” (vol. 368 no. 8336, Aug 9-15, 2003, pp 19-21).*

*This article was extracted from a longer report and edited by Robyn Forrest, Sea Around Us Project.*

