Public Policy Statement

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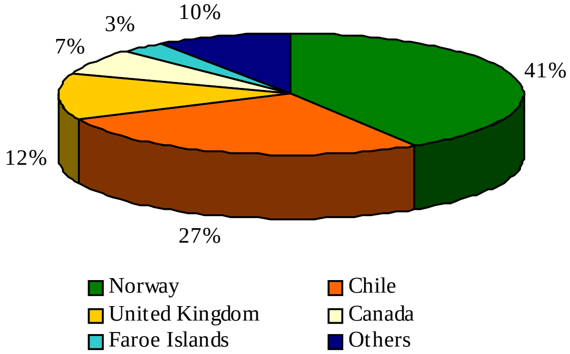
Fishermen to Fish Farmers of the Sea: Aquaculture in Chile

Salmon is not native to Chilean waters. Trout was introduced in Chile in the locality of Río Blanco during the early part of the 20th Century.[1] Intensive aquaculture systems began on the threshold of the 80's.[2] The high level of productivity was justified in terms of the need to reduce pressure on marine resources. These were being greatly exploited due to the increase caused by the world demand for protein extracted from the sea. The basic idea was to increase the supply of this nutrient and at the same time prevent, through controlled fish farming, the possibility of shortages. That is the way the then-ruling government understood it and thus gave incentives and support to the creation of fish farming centers.[3]

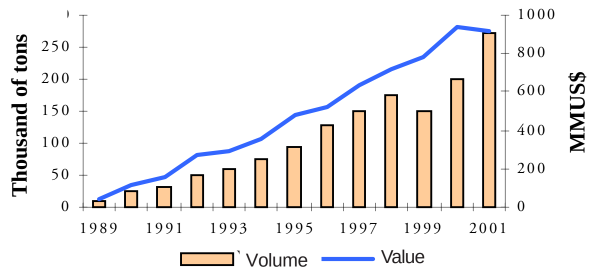
The accelerated industrial growth can be appreciated by comparing the production figures: 80 tons at the beginning of the 80's, 500 tons in 1984 and 4 years later more than 5,500 tons. Beginning in the 90's, the industry gained strength. Two figures dramatize this fact: in 1997, 247,970 tons of salmon and trout were produced and in the year 2000, 206,000 tons were exported.[4]

Graph 1: Salmon Producers (2000)



Source: Salmon and Trout Producers' Association

Graph 2. Trend of the Volume and Value of Salmon and Trout Exports



Source: Banco Central

The salmon industry is mainly located in the tenth region of Chile (40°30' south latitude: 72°50' west longitude) but recently it began to spread into the eleventh region which is a little farther south.

II. The Successful Figures of Chilean Salmon Farming

The preceding figures show how during the 90's, aquaculture in general and specifically salmon

[1] Untranslated book: La Ineficiencia de la Salmonicultura en Chile, 2000
[2] Ibid.
[3] Ibid.
[4] Ibid.

Executive Summary

Environmenal Impact of Aquaculture

The State of Investigation in Chile and the World

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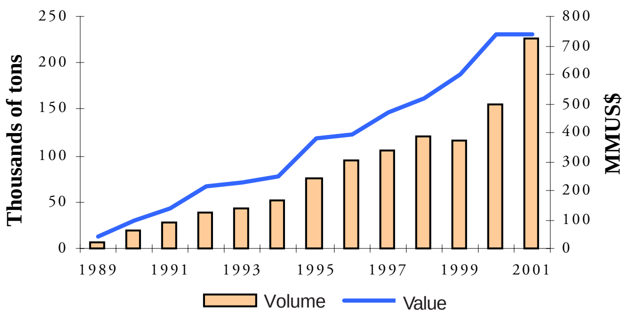
experienced explosive growth in Chile. This phenomena has shown amazing strength as salmon and trout exports reached US$973 million in the year 2000, very close to the US$1 billion goal previously set by the Salmon and Trout Exporters Association for that year, with 206,000 tons being exported. This figure generated optimistic estimates showing projections that salmon farming would triple in exports and income by the year 2010.[5]

The declared objective by the national exporters is to attain a goal of US$3 billion in exports by the year 2010. This means tripling the physical volume exported, if the prices remain relatively constant (see graphs 2 and 3)

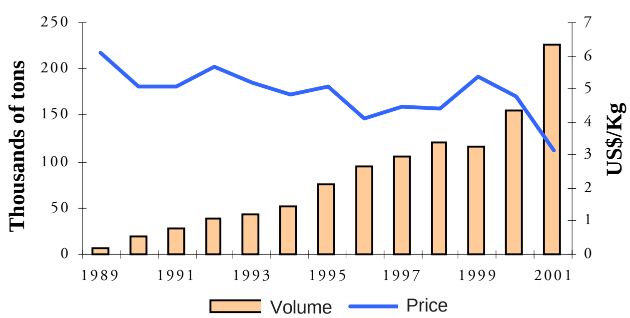
Graph 3. Trend of the Volume and Value of Salmon exports



Source: Banco Central

A saturation of the international market during 2001 caused Japan and Norway to limit their salmon production and sparked reasonable concern that this situation was due to the enormous amounts of salmon that Chile was flooding into the world market during the past decade.

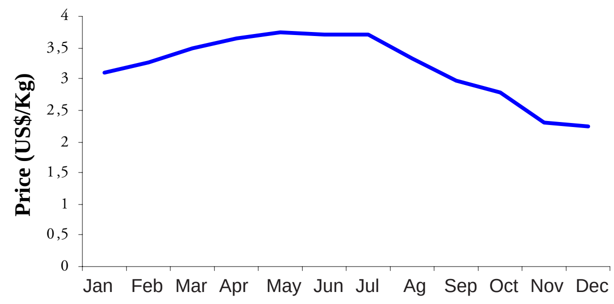
Graph 4. Trend of the Volume and Price of Salmon exports



Source: Banco Central

Graph 4 shows a relationship between the volume and value that makes apparent that the Chilean production during the final quarter of 2000 increased. Graph 5 shows the price tendency during the past year for this commodity where a drop in price begins in May.

Graph 5. Trend of salmonidae prices, 2001



Source: Banco Central

By the end of the year 2001, the economic panorama of the Chilean salmon exporters was radically different from the estimates given during the first few months of the same year: US$964 million in export income, almost 1% less than the year 2000 with 300,304 tons exported, almost 46% more exported, compared to the previous year, which means that the average price for the year 2001 decreased by 32% relative to the year 2000.[6]

III. Environmental Impact of Salmon Farming[7]

Extensive salmon production has subjected the ecosystems of southern Chile to an intense

[5] Untranslated magazine, AguasNoticias, April 6, 2001
[6] www.salmonchile.cl, February 4, 2002
[7] Taken from the untranslated document "Impacto Ambiental de la Acuicultura: el estado del conocimiento en Chile y el Mundo" based on a study of the evidence published by diverse groups of scientists located in different geographical regions, as well as Chile. This study gives a conceptual foundation and describes the environmental problems associated with aquaculture (chapter 2). It continues with a discussion of methodological approximations to determine the effects of this activity on the aquatic ecosystems (chapter 3), to, later, give existing evidence about the concrete effects that this activity has on the environment (chapter 4). Later it analyzes the existing evidence in Chile (chapter 5). With the environmental effects revealed, it indicates methodological approximations which have been used to evaluate economically the impact produced by the aquaculture industry (chapter 6). Finally, technological alternatives and production strategies are presented which tend to minimize the environmental impact (chapter 7) and recommendations and conclusions are offered (chapter 8), Buschmann, Novemeber, 2001.

transformation produced by human activities. These diverse and multiple effects upon the environment could possibly affect human health[8] as well as biodiversity.[9] On many occasions, the conflicts of interest generated by the initiatives required to mitigate this environmental impact make the discussion difficult, stopping concrete measures of action from being taken.[10]

Aquaculture impacts the environment in three ways: the consumption of resources, the process of transformation and the production of the final product.[11] To achieve its objectives aquaculture requires a wide specter of raw materials distributed over a large geographical area which when transformed produce a high concentration of waste in a specific area.[12]

It has been estimated that in different regions more than 60% of the phosphorus (P) and 80% of the nitrogen (N) caused by salmon farming waste end up in the water columns.[13] These changes in the water column include increases in the levels of nutrients (N and P) and the amount of dissolved organic material, as well as a reduction in the concentration of dissolved oxygen, alteration of the pH[14] and changes in both the level of conductivity and transparency of the water.[15]

3.1 Raw materials and the consumption of resources:

Water as well as *space* are essential for aquaculture development. Their use generates permanent conflicts due to environmental impact (levels of oxygen, quantity of nutrients, reservoir of diseases) as well as the social tension caused by conflicts with other productive activities (artisan fishing, tourism, cultivation of algae, etc.). Additionally, *the construction materials* for the aquaculture installations, *the chemicals* used in the cultivation labors and the introduction of foreign *roes* are elements which alter the environmental conditions of the ecosystems and whose effects have still not been studied sufficiently in Chile.

Apart from the previously mentioned items, there is another element, *the feed*, one of the primary raw materials for animal aquaculture. The production, especially of fish and crustaceans (organisms of a high trophic and carnivorous level) has been developed based on the fish meal industry. In the mid-nineties, the world production of Atlantic salmon was approximately 400,000 tons and assuming a feed conversion factor of 1.3:1, we see that this production required 520,000 tons of feed. If we consider that the salmon's diet contains 50% fish meal and that it takes five tons of fish to make one ton of fish meal, it can be estimated that to sustain the production of atlantic salmon, 1.3 million tons of fish[16] are needed annually, or in other words, three kilograms of fish are needed to produce one kilo of salmon.

This data indicates that the demand for fish meal represents 15% of the of the world production and 5% of the fish. Current information ascertains aquaculture of carnivorous organisms is supported but with an extreme pressure being placed upon the fishing industry which in turn causes modification of habitats in areas of fishing activities.[17]

3.2 The Process of Transformation

Installation of cultivation centers: The installation of production centers in which floating cages, floating lines and others systems are used, means an increase in human activity and the level of noise produced.[18] This has adverse effects on the native wildlife both in the specific location as well as along the bordering coastal zones and the service roads near there. Moreover, fish farming in a specific area attracts predatory animals, which in turn can cause either the accidental or deliberate deaths of these predatory animals.

3.3 Production of the final product:

Aquaculture production ends with both product and *waste*. *The waste* can have many forms, such as: plastic and metal structures, non-consumed feed, excretion,

8 Clark, 1991
9 Caughley and Jun, 1996
10 Untranslated document: Impacto Ambiental de la Acuicultura, el estado del conocimiento en Chile y el Mundo, Alejandro Buschmann, November, 2001.
11 Ibid.
12 Folke and Kautsky, 1989
13 Petterson, 1988; Holby and may, 1991; Wallinand Häkanon, 1991 a,b; Hall et al., 1992
14 Expreses the concentration of protons (pH= -log[H$^+$], and indicates the acidic level of a solution. The pH scale goes from 0 to 14. A substance that is neutralñ is pH=7, an alkaline has a pH greater than 7 and an acid has a pH that is less than 7.
15 Brown et al., 1987; Hall et al., 1990; 1992; Cho and Bureau, 1997
16 Beveridge, 1996.
17 Naylor et al., 1998; 2000.
18 Beveridge, 1996.

excrement, chemicals, microorganisms, parasites and non-native animals.[19] Of the total amount of feed used in salmon production, about 25% of the nutrients is consumed while the other 75-80% remains in the environment in one form or another. A significant amount of this waste falls to the marine floor and another portion of it remains in the water column. The local concentration of nutrients produces multiple environmental effects.

Use of chemicals to combat the parasites, fungi and bacteria also produce residue which stay in the environment producing diverse effects upon the biota. In addition to the contamination by organic material, another is added by the chemical agents used in specific practices of aquaculture. Among these are some elements such as construction, corrosion protection and anti-stick against incrustive organisms along with others which are habitually used in cultivation activities such as pigmentation in the feed, disinfectants and different products used to control diseases.[20]

The most significant products, because of the quantity, used especially in fish farming are the different medications required to combat diseases. These medications comprise a large variety of products such as antibiotics, anti-fungicide and anti-parasite compounds like *green malchite*.

Currently it is recognized that the antibiotics can be present hundreds of meters from the cultivation systems, remain potent in the environment for more than two weeks after being administered and antibiotic residue[21] can be found in organisms which have eaten the feed remains. This represents an alert warning concerning the consumption of these organisms by man.[22]

Green malachite is used for ectoparasite control and it is applied by bathing the infected fish in it. If the chemicals are then washed off into bodies of water, these will affect other organisms such as different crustacean larva. Nevertheless, other studies have not been able to verify an effect upon the mass of invertebrates[23] and so this issue should be studied cautiously.

3.4 The Ecological Fingerprint

All of the activities that are necessary for the functioning of a cultivation center, from the making of the feed to the transport and transfer of the raw materials due to the demand required by aquaculture can be explained by the concept of "ecological print". This term refers to the space requirement of water as well as land which is necessary to provide resources, services y energy to the specific production area.[24] Studies carried out in different parts of the world indicate that the area required to guarantee the function of one hectare of salmon cultivation is an area at least 10,000 times greater.[25]

IV. Investigations in Chile

In Chile, of the 823 aquaculture centers which were authorized and producing during 1998, 81% are in the tenth region[26], due to the availability of adequate sites for the different aquaculture practices.[27] In this region, there are 268 salmon cultivation centers, 130 mollusk cultivation centers and 271 algae cultivation centers.[28] Of the different aquaculture activities, in Chile the primary one is salmon farming which currently represents 72% of the national production with its 259,000 tons in 1998.[29] 87% of this production comes from Chile's tenth region, which means a volume of approximately 226,000 tons.[30]

4.1 The Process of Salmon Farming in Chile

The development of salmonidae aquaculture requires fresh water to begin the cultivation, incubating the roes until juvenile fish are produced according to a phase called smolting.[31] This phase of smolting corresponds to fish in a physiological stage such that they can regulate their osmotic potential[32] when transferred to sea water. The continental water reservoirs existing in

[19] Beveridge, 1996.
[20] Alderman et al., 1994; Beveridge, 1996.
[21] Lunestad, 1992; Samuelsen et al., 1992.
[22] Yndestad, 1992.
[23] Murison et al., 1997.
[24] Folke et al., 1998.
[25] Folke et al., 1998.
[26] Anonimous, 1999.
[27] López et al., 1988; Buschmann et al., 1997
[28] Anonimous, 1999.
[29] Anonimous, 1999.
[30] Anonimous, 1999.
[31] Boeuf et al., 1992.
[32] Capacity to regulate metabolism in waters with different salt concentrations.

southern Chile have a high level of water quality: the lakes are deep, exceptionally oligotrophic[33] and have transparent and crystalline waters.[34]

The most outstanding case is Lake Llanquihue, where almost 80% of the salmon smolt is produced, with 2,500 tons of production per year and an added contribution of 40 tons of phosphorus which is equivalent to 13% of the total amount which enters the lake.[35] However, in spite of the significant deposit of nutrients into the system, the lake maintains its relatively pristine nature, indicated by the levels of chlorophyll, dissolved phosphorus and water transparency. It is necessary to note that these nutrients have doubled in quantity during the past ten years.

Similar conclusions have been reached regarding other lakes like Ranco.[36] It appears that the oligotrophic lakes of southern Chile have different mechanisms of resistence to eutrophication[37] which have permitted them to maintain their oligotrophic conditions, though data is still unclear in this matter.

In spite of past experience, this condition can be lost at any moment. Mühlhauser and his collaborators[38] describe how the secondary bacteria production under the floating salmon cages in Lake Cucao, in Chiloé, increased in relation to control sites at distances from the cultivation centers.

During the salt water stage, the fish cultivation is carried out in bays and marshes of the tenth region. Studies carried out in experimental systems have shown that the accumulation of organic material under the small floating cages can be quite significant, such as the increase in the number of benthonic predators. However, no changes have been detected in the abundance or the richness of the foraminifer species.[39]

Other studies carried out at five cultivation sites indicate that the effects on the sediment and abundance of macro fauna are minimal.[40] Its authors indicate that the gastropod *Nassarius Gayi* increases its abundance in places where there are salmonidae cultivation centers. Although studies done by Larrain[41] were carried out in various environments, since the sample design is not indicated nor is there statistical analysis of the information, it is difficult to evaluate the results.

Another document[42] indicates that the bacterial production in the sediment under the floating cages installed in the coastal zones is not significantly different from that in the control sites located 50 to 100 meters away. The monitoring program was done in the mid-90's in Metri Bay with a water depth of 8 to 15 meters in the cultivation area and currents greater than 12.5cm s^{-1}. This program collected information before and after the initiation of the cultivation activities both in the impacted areas as well as in the control sites, considering replicas within and among the zones.

The results of this study are summarized in chart 5 from which it can be concluded that two years after the cultivation system installation with a production of 90 to 150 tons per year, there was a significant statistical increase in red algae *Sarcothalia Crispata*, the mollusk *Crepidula sp.*, the polychaete *Capitella sp.*, as well as amphipods and ostracods, present on the sandy marine floors under the floating cages and dinoflagellata in the water columns.[43]

By using distinct indexes of ecological diversity, Vergara (2001) only detected that a certain number of species present on the soft marine floor showed a significant but temporarily increase indicates a sporatic increase in the dominance of some benthonic species found at the cultivation sites.

[33] Lakes with very clean and crystalline waters without organic contaminants.
[34] Soto and Stockner, 1996.
[35] Soto and Campos, 1995
[36] Soto and Campos, 1995.
[37] Soto and Stockner, 1996.
[38] Mühlhauser et al., 1993.
[39] López et al., 1998.
[40] Larrain et al., 1993.
[41] Larrain et al., 1993.
[42] Mühlhauser et al., 1993
[43] Vergara, 2001

In 1988 there were massive fish deaths associated with a spectacular flowering of the microalgae *Heterosigma Akashiwo*.[44] Since this event occurred, a monitoring program has been established in the coastal zones of the tenth region. The results do not indicate that there is a correlation between the aquaculture activities and the abundance of phytoplankton.[45] Nevertheless, the studies done by Vergara[46] show a significant statistical increase in the dinoflagellata in the proximities of the fish cultivation sites. Given that some of these species can cause red tide, this issue will require special attention in the near future.

Existing diseases in Chile: In intense salmonidae cultivation, important pathologies have been detected, such as the bacterial disease of the kidney (BKD), one of the most important in Chile[47]; to which other new diseases must be added: such as *septicemia rickettsial* identified for the first time in 1989 and which has caused losses to the Chilean industry.[48]

The presence in Chile of the "Coho Salmon Syndrome" initially known as "UA" (unidentified agent) and first reported in 1989,[49] has caused since 1981 a significant number of deaths of this salmonidae[50] in the commercial cultivation centers, and has been identified in Chilean lakes by Bravo.[51] The continual transfer of Coho Salmon breeders from the ocean to the lakes might be the means by which this pathological agent has gone from the ocean, its natural environment to a new one, the fresh water lakes of Chile.[52]

Another important component of the existing pathologies in salmonidae cultivation and the native fish population is the presence of the ocean lice *Caligus Rogercresseyi*.[53] This salmonidae ectoparasite copepod also has caused important economic losses and to combat it, chemical treatments[54] have been used which unfortunately have had toxic effects on marine life and human health.[55]

Use of antibiotics in the Chilean aquaculture: The treatment for these diseases requires the use of different types of medications, among which the most widely used are antibiotics. Apparently, but without exact information, it has been determined that the use of antibiotics in Chile greatly exceeds the quantities used in other countries dedicated to aquaculture, such as the case of Norway.[56] There is a lack of information about how these antibiotics and other medications are administered in Chile; if they are incorporated into their diet, which would mean a significant release into the environment or if they are directly applied through vaccinations with a higher level of specification for the control of the diseases. Clearly the lack of information along with the effects upon the environment are issues which require urgent attention.

The predators of Chilean aquaculture: Counts of common sea lions carried out between 1998 and 1999 for the tenth region showed 13 reproductive colonies and 19 transitional resting areas for the common sea lion. The average number of individual Otaria Flavescens was estimated at 29,352 in January and 28,025 in March, 1998 and it has been documented that there exists an inverse relation between the presence of salmonidae cultivation and common sea lion packs. Consequently, one of the most probable causes for the disappearance of sea lion packs would be the increase in the mortality of the individuals, deliberately or accidentally carried out by the workers at the salmonidae cultivation centers, as a preventative measure to avoid economic losses caused by the sea lion attacks on the floating cages. As a result of this interaction, the death of 5 to 6 thousand sea lions has been documented as caused directly or indirectly by the salmonidae cultivation centers.[57]

4.2 The Need for Research in Chile

To accurately and objectively examine the current production technology being used in the area of salmon farming, it is necessary to know and quantify its environmental impact which is extremely difficult because of the lack of records and information in Chile.[58]

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[44] Clement and Lembeye, 1993.
[45] Clement and Lembeye, 1993.
[46] Vergara, 2001.
[47] Campalans, 1990.
[48] Fryer et al., 1990; Cvitanich et al., 1991.
[49] Bravo and Gutiérrez, 1991.
[50] Branson and Nieto, 1991.
[51] Bravo, 1994.
[52] Smith et al., 1996.
[53] Carvajal et al., 1998; González et al., 2000; and Carvajal et al., 2001.
[54] Marín et al., 2001.
[55] E.g. Rose et al., 1998; Burka et al., 1997; and Collier & Pinn, 1998.
[56] Caro, 1995.
[57] Terra Australis, 1999.
[58] Buschmann et al., 1996.

Although for many years there has been a need for serious methodological studies regarding this subject,[59] it seems that we are still in a situation of almost complete ignorance concerning our environment and of what is occurring in it. Knowing that salmon farming produces diverse effects upon the environment,[60] it is necessary to know and quantify these effects through systematic and reliable methodologies[61] with the goal of making production and development interests compatible with the protection of the environment.[62] Only a rigorous, objective and transparent evaluation will allow for development which has a greater level of sustainability.

V. The Environmental Costs of Chilean Salmon Farming[63]

As has been mentioned, aquaculture has diverse and multiple effects on the environment among which are those produced by the organic waste of the fish and the residue of the feed whose principal effect is the eutrophication of the water.

The quantity of nutrients which produces a ton of fish, in captivity, has been diminishing since 1974, from 31 kilograms of phosphorus (P) and 129 kilograms of nitrogen (N) to approximately 9.5 kilograms of phosphorus and 78 kilograms of nitrogen in 1994, primarily due to the changes in the make-up of the food and the improvement of the conversion indexes.[64] These values, considering the gross production of 100 tons of salmon, mean a secondary production of 78,000 kilograms of nitrogen and 9,500 kilograms of phosphorus per day depending on the methods used and quality of the fish food.

Organic, urban and/or industrial waste have the same potential for eutrophication of water as does the production of fish in captivity.[65] In the case of man, the average, daily production of waste is 1.5 grams of phosphorus and 10 grams of nitrogen. Considering these values, 100 tons of fish, grown in captivity, produce the same amount of chemical waste as do 2,800 to 3,200 people in developed countries.[66]

The production of 80,000 tons of salmon in Chile during 1994, would have produced then, an equal amount of waste as 2.2 to 2.6 million people, which is 3 times greater than that produced by the entire human population that lives in the salmon production zone.[67]

Another figure: During the year 2000, 345,000 tons of salmon and trout were produced in Chile, thus producing an equivalent amount of waste to that of 9.6 - 10.9 million people. But, let's assume that because of better management and technology in feeding during the past 5 years, that the figures for nitrogen and phosphorus have dropped to 33 and 7 kilograms, respectively, per gross ton of salmon produced.[68]

Given the fact that salmonidae production has increased significantly since 1994, to reach 342,000 tons in the year 2000,[69] the level of waste generated by the aquiculture production would be equivalent to that of a human population of 3.03 - 4.6 million inhabitants. This shows that in spite of the efforts to improve the technology used, expansion of the industry continues to produce a sustained growth of waste which impacts the environment.

Information concerning the cost of waste treatment is necessary to be able to calculate the environmental costs of the Chilean aquaculture industry but this data is not available in Chile since waste water treatment is new here. For this reason, values from developed countries have been chosen and can be used with the proper restrictions to analyze the environment costs associated with the Chilean aquaculture industry.

In Sweden, the cost to eliminate nitrogen from a certain volume of water varies from 6.4 to 12.8 US$ per kilogram while the removal of phosphorus costs 2.6 to 3.8 US$ per kilogram.[70] Since these are the prices that are currently charged, they should be considered that which the industry is willing to pay for waste water treatment.

59 López et al., 1988; Buschmann et al., 1996.
60 Ervik et al., 1997.
61 Panchang et al., 1997.
62 Hurtubia, 1988; López and Buschmann, 1991; Spash, 1997.
63 This segment is an extract from the document "The Environmental Cost of Salmon Farming inChile", prepared by the economist Rodrigo Pizarro based upon the the records collected by Alejandro Buschmann, marine biologist from the "Universidad de los Lagos" in the untranslated document "Impacto Ambiental de la Acuicultura: el Estado de la Investigación en Chile y el Mundo", November, 2001.
64 Enell and Ackerfors, 1991.
65 Persson, 1992
66 Folke et al., 1994.
67 Buschmann et al., 1996
68 Sernap, 2000
69 Folke et al., 1994.

Chart 1. Cost of Environmental Impairment Ambiental in the Aquaculture Industry

Year	Production of Salmon and Trout	Waste estimates		Cost US$/ton Nitrogen		Cost US$/ton phosphorus		Total environmental cost US$ Millones	
		Nitrogen	Phosphorus	Low	High	Low	High	Low	High
	Tons	kg/ton	kg/ton	6.4 US$/Kg	12.8 US$/Kg	2.6 US$/kg	3.8 US$/kg		
1990	28,615	78	9.5	499.2	998.4	24.7	36.1	14.99	29.60
1991	42,480	78	9.5	499.2	998.4	24.7	36.1	22.26	43.95
1992	62,147	78	9.5	499.2	998.4	24.7	36.1	32.56	64.29
1993	77,475	78	9.5	499.2	998.4	24.7	36.1	40.59	80.15
1994	101,958	78	9.5	499.2	998.4	24.7	36.1	53.42	105.48
1995	141,377	33	7	211.2	422.4	18.2	26.6	32.43	63.48
1996	199,085	33	7	211.2	422.4	18.2	26.6	45.67	89.39
1997	247,970	33	7	211.2	422.4	18.2	26.6	56.88	111.34
1998	259,236	33	7	211.2	422.4	18.2	26.6	59.47	116.40
1999	230,188	33	7	211.2	422.4	18.2	26.6	52.81	103.35
2000	342,406	33	7	211.2	422.4	18.2	26.6	78.55	153.74

Source: SERNAP, Buschmann, et al 1996, Folke 1994

It is true, that because of lower income, the willingness to pay that price in Chile is less, nonetheless, the effective costs of removal would be about the same.

If we consider these prices and the level of production in Chile, during the decade of the 90's, an estimate can be made of the annual environmental cost caused by the discharge of nutrients from salmonidae production. The cost has been estimated for the 90's. The results of the calculations are to be found in Chart 1. The environmental costs generated by this sector for the year 2000 is estimated to be US$78 to 153 million . This figure is high since other environmental damages have yet to be considered.

To properly understand the dimensions of these figures, it is necessary to use the GDP for the fishing sector. In the year 2000, it reached US$1,205 million but this included other activities not associated with salmon-farming, such as the production of algae and other species, and fishing by family-owned and industrial companies. Without making a specific estimate of the GDP for salmon-farming, that is to say, the value added generated by salmon and trout production, a rough estimate is 40% of total fishery (fishery excludes fish meal)[70]. With these calculations in mind, an estimate of 16-32% of

Chart 2. Aquaculture: Sectorial GNP and Environmental Costs of Aquaculture

Year	**Fishing GNP mm pesos 1986**	**Fishing GNP mm US$**	Environmental cost US$ Million		Environmental Cost/Aquaculture GNP	
			Low	High	Low	High
90	54,685	466	15	30	8%	16%
91	60,275	633	22	44	9%	17%
92	70,281	798	33	64	10%	20%
93	74,195	691	41	80	15%	29%
94	86,316	786	53	105	17%	34%
95	100,040	932	32	63	9%	17%
96	109,771	993	46	89	12%	23%
97	120,014	1,100	57	111	13%	25%
98	122,947	1,055	59	116	14%	28%
99	125,032	1,050	53	103	13%	25%
00	146,151	1,205	79	154	16%	32%
01	160,580	1,145	80	157	18%	34%

Source: Banco Central, Buschmann y Pizarro

[70] This is a rough estimate that the exports for the year 2000 generated about U$1 billion and the value added sector represented 50% of the gross value of production for that year, or in other words, U$500 million. However, this is a high estimate. Within this sector are included other aquaculture production, artisan fishermen and fishing boat factories and industries. Therefore this should be considered as a maximum quota.

the value added generated by salmon-farming, should be set apart for environmental costs or consumption of environmental capital. The sum total of the environmental costs during the period 1990-2000 would be between US$490-961 million . See Chart 2 for greater details concerning this figure.

Another way to look at these results is to consider that the value of salmonidae varies between US$ 3.1 and US$ 3.5 per kilogram (FOB), but if these environmental costs were included, the price would increase 15-57% depending on the amount of nitrogen and phosphorus in the feed.

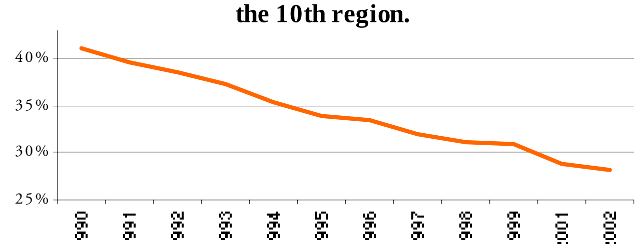
Since the price has decreased from approximately US$5 per kilogram at the beginning of the 90's to values of less than US$4 and even less than US$3 during the year 2001, it is to be assumed that the Chilean salmonidae industry would not be capable of covering the environmental costs unless high quality feed is used in a well-ordered fashion.

VI. Social Impact

In addition to the environmental aspects, the social impact is very important when considering any project that deals with sustainability. The theory that this set forth is that the goal of any activity is to guarantee a ever-increasing well-being of the workers reflected by an improvement in employment, income, working conditions and especially in the area of safety. In all of these cases, coherent growth is hoped for according to the increase in production and the level of returns of the industry.

This is an issue that the salmon farming sector has severely neglected. According to a press release emitted by the president of the Central Unitaria de Trabajadores (workers' union), Luis Sandoval, the majority of the salmon industry employers do not pay maternity leave, pay such low salaries that they do not reach minimum wage (U$160 per month) and keep the workers in a permanent state of risk because of minimum standards of workplace safety. This is in addition to a lack of basic services and the constant pressure against workers who are actively involved in the union (known as anti-union tactics).

Graph 6. Job positions in agriculture, hunting and fishing in relation to total job positions in the 10th region.



Source: INE

According to the National Institute of Statistics (INE), during the period of 1990-1999, in the tenth region there was an increase in the relatively stable and moderate labor force. The most important sectors in job creation were: agriculture; hunting and fishing; communal, social and personal services; manufacturing and commerce.

Although employment has dropped in the sectors of agriculture and hunting and fishing, these continue to be the most important areas for employment.[71] However, during the period 1990-1999, 12,163 jobs were lost in these sectors but that decrease was made up partly by other sectors. So, it can be seen that there is a tendency toward a decrease in the number of jobs within the agriculture and hunting and fishing sectors (where the salmon industry jobs are to be found) in relation to the total number of workers in the region[72] .

On the other hand, at the same time that the national and transnational intensive salmon monoculture companies have grown and capitalized, the tenth region

Chart 3. Monthly salaries of the workers in the 10th region according to the size of the fishing company

Number of workers (Range)	Net salary US$
<10	190.00
10 a 49	225.00
50 a 99	215.00
100 a 149	211.00
150 a 299	210.00
>300	232.00
Average income	214.00

Source: Universidad Arcis, 1999

* The 23 plants represent 20% of the 10th Region Universe

[71] Informe de Recursos 2000, Fundación Terram
[72] Ibid.

continues to be among the three poorest areas in the country, with 20,5% of the population living in poverty. To this you must add an environment which is continually weaker and the growing conflicts between artisan fishermen and the salmon companies.

A labor issue that has caused serious problems within the salmon industry is the large number of temporary job placement services which supply short term workers to the large companies which then feel no obligation toward the workers, especially in the areas of social security and legal benefits. Under this system, labor is cheaper because necessary expenses are avoided.[73]

VII. Public Policies relating to the Salmon Industry: "Go forward but make no Assessments"

Even though the salmon farming sector has many issues to clarify regarding the sustainability of its practices and viability for becoming an effective instrument for development in the country, it continues to be looked at by the financial authorities as the current and future economic motor for the southern most regions of Chile. This zone is its objective and all gestures indicate that soon the final expansion will be completed into the entire territory by this productive sector.

7.1 The General Law of Fishing and Agriculture.

During its first few years, the aquaculture industry grew throughout all of the tenth region of Chile without any legal system which regulated its growth and the progressive expansion of its cultivation centers. Only recently, in 1989, was the General Law of Fishing and Agriculture approved. The year prior to the approval, the industry produced 5,500 tons of the specie, a quantity which seems low when compared with the current figures but if compared to preceding years, it shows a tendency toward accelerated growth within this sector which exploits natural resources and which in less than a decade from that time has increased it production by more than 30 times what it was.

With the publication of the General Law of Fishing and Agriculture, the first criteria was established to govern this sector but it was very superficial due to a lack of key elements such as the Regulations for Concessions and Authorizations for Aquaculture, Environment Regulations and the Sanitary Code.

It wasn't until 1994 that the General Law regarding the Environment which established the regulations for the Evaluation System for Environmental Impact would contain the criteria for submission to and evaluation of the businesses which work directly related to the environment. Salmon farming is included among these activities. However, this system only went into operation after the other regulations were approved in 1997. That is to say that during a large part of the decade of the 90's, this industry continued its rapid expansion without any environmental regulations which would validate the sustainability of its practices. By that time the salmon producers were generating 104,607 tons of product per year with an income of U$337 million.[74]

On July 7, 2001, the Regulations for Concessions and Authorizations were officially made law as Supreme Decree 275 by the Economic Ministry. This would legally open the way to resolve the issue of more than 580 pending requests for concessions and authorizations for different types of cultivations. Of these detained requests 117 were for the eleventh region and of these 99.1% were for salmon cultivation and 0.9% for mollusk. The most important factor was that a time frame was set for the approvals to be given through the Environmental Impact Evaluation System.

Of the 580 pending requests, 218 were for salmon and 5 more for salmon and mollusk. The modification of the norms is of great relevance given that it would create incentive for aquaculture development (salmon farming) in the region, especially in the tenth region where there are 392 concessions on hold while there are 117 in the eleventh and only 56 in the twelfth.

VIII. Subsidies

There are two types of subsidies available to the industry. They are Supreme Decree 889 which promotes hiring in the extreme southern regions of Chile and Chiloé. The subsidy represents up to 17% of the salary, up to U$40 per month.

[73] Ibid.
[74] Association of Salmon and Trout Producers, www.salmonchile.cl

The other is the Austral Law which is applicable to the same zone and allows a tax credit of up to 40% of the investment to be claimed through the year 2028. This can be very beneficial to the aquaculture industry and especially for their projected expansion into the eleventh region.

To date there are no studies which would allow it to be determined how many aquaculture companies have taken advantage of these subsidies.

IX. Some Final Thoughts

Although different people know the impact generated on the environment by the industry, there are distinct opinions about the capacity of effective charge into the marine ecosystems and the fresh water lakes of Chile as well as the benefits of the industry to the local communities.

In the first case, only a serious scientific investigation, with specific samples can demonstrate the real impact of the industry. Particularly it is important to differentiate between serious and chronic effects. However, with international evidence available, the guiding principle would suggest to use caution with such explosive expansion because of the possibility of causing irreversible damages.[75]

Regarding the second aspect, it is important to point out that all economic activities generate benefits to the local communities but the question should be, how many and what is their long-term cost.[76]

The weak Chilean regulatory sustem and the absence of adequate fiscal control could cause enormous future environmental problems and social conflicts which would limit the aquaculture industry´s projections into the future. Consequently, it is to the industry´s advantage to have expanded fiscal control over their activities. Truly, it is not for the purpose of stopping the industry but instead to generate instruments of control which guarantee development within a framework of sustainability.[77]

An activity such as the aquaculture industry will be subject to permanent questioning both within and outside of the country[78] due to the serious environmental impact because of the overexploitation of the marine biomass, over which there is practically no regulatory guidelines because of inadequate and inefficient control. Furthermore the worker salaries are miserable and the company profits are enormous. Moreover, the industry is subsidized by the few resources that are available to the government.

It is necessary for the Chilean government to revise its method of granting aquaculture concessions in the South. Minimum public opinion demands a serious evaluation of the strategy to promote the development of this industry, not only in economic terms regarding future accusations of dumping but also because the principle of using caution regarding the environment requires that the national authorities evaluate whether to sell the natural resource base of southern Chile or not.[79]

[75] Rodrigo Pizarro, Research Director, Terram Foundation. Direct reference.
[76] Ibid.
[77] Ibid.
[78] Ibid.
[79] Ibid.

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THE TERRAM FOUNDATION

The Terram Foundation is a non-governmental organization born in 1997 through the combined efforts of a group of professionals from different backgrounds, committed to creating an institution which would stimulate a renewal in political, social and economic thinking. Today the institution is directed towards strengthening three areas of action: serious research into economic and environmental problems, legal actions and public communication. The overall objective of the institution is to generate proposals for sustainable development in Chile.

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