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The Competitiveness of the Chilean Salmon Aquaculture Industry

by

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Abstract
Commercial salmon and trout farming has emerged as a major industry in Chile during the 1990s. Salmon is not a native species to Chile, still excellent climatic conditions are provided for farming. Since 1992 Chile has been the second largest producer of farmed salmon and trout in the world after Norway. This report reviews the development of the Chilean salmonid industry from its early stages until today with respect to production patterns, legislation and main markets. A cost comparison between Chilean and Norwegian farmed salmon is also provided. Finally, the international competitiveness and future challenges of the Chilean salmonid farming industry are analysed.

Acknowledgements

This report is based on Bjørndal and Aarland (1999), Norheim (2000) and interviews with Chilean industry and government officals. Sandra Taub of Aquanoticias has kindly assisted with providing data.

1. INTRODUCTION

Salmon aquaculture has become a major industry in many countries. In the early 1970s Norway was the pioneering country in the field. The initially modest quantities fetched high prices, which gave good incentives for other countries to enter the market. In 1979 salmon farming began in Chile, and by 1992 Chile was the second largest producer of farmed salmon after Norway.

The purpose of this report is to analyse the competitiveness of the Chilean salmon aquaculture industry. I will look at the expansion of production and exports and study the conditions giving rise to the Chilean salmon success. The structure of the industry will be examined together with cost of production, and a cost comparison between Chilean and Norwegian salmon farmers will be presented. Furthermore, the US and Japanese markets will be investigated, and finally the current and future expected competitiveness of Chilean salmon industry, vis-à-vis the Norwegian, will be discussed.

2. THE CHILEAN SALMON AQUACULTURE INDUSTRY

From the very beginning, the worldwide production of farmed salmon has been dominated by a few nations. Four countries supply around 80% of the total production. These are Norway, Chile, the UK and Canada. Their production over time is illustrated in figure 1.

Two trends dominate the picture in figure 1. The first is Norway's leading position throughout the whole period. In 1981 its share in world production was approximately 70%. Its dominance has been reduced over time, though, and Norway's share had decreased to just about 47% in 1999 and 43% in 2000. As 1999 saw reduced output in Chile due to the economic crisis in Asia and in Scotland due to disease problems, Norway's share actually increased that year. The second important trend is the rise of Chile as a major producer of farmed salmon. From a zero share in world production at the beginning of the 1980s, the production rapidly increased in the late 1980s and had surpassed that of both the UK and Canada by 1992, making Chile the second largest producer of farmed salmon in the world. In 1998 Chile's share in world production was about 22%, falling to 20% in 1999, but increasing again to 24% in 2000. The shares of Canada and the UK have been more stable.

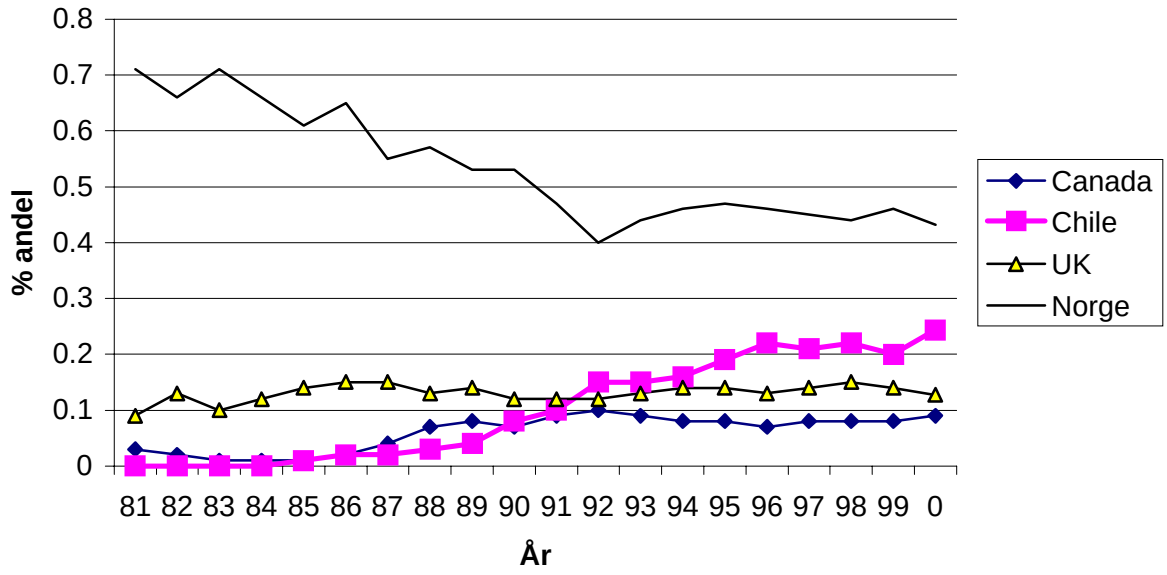


Figure 1. Shares in World Production of Farmed Salmon 1981-2000

An important factor explaining the development in a country's production share is usually the development in its production costs relative to other countries. As noted, Norway's production share declined substantially in the period under consideration. This decline was probably bound to happen due to diffusion of best-practice technologies from Norway to other countries. Nevertheless, developments in cost of production may also have been important. Furthermore, trade measures such as those Norway has experienced in the European Union market also affect the production share.

Salmon Production.

The Chilean salmon aquaculture industry is concentrated around Puerto Montt and the Chiloé Island in region X, about 1,000 km south of Santiago, but extends also into regions XI and XII. Due to their rugged coastline these areas offer sheltered sites with ideal water temperatures and salinity. Low population density contributes to unpolluted fresh water sources, and the numerous lakes which do not freeze in winter present stable, favourable climatic conditions for smolt production throughout the year. A map of Chile is provided in figure 2.

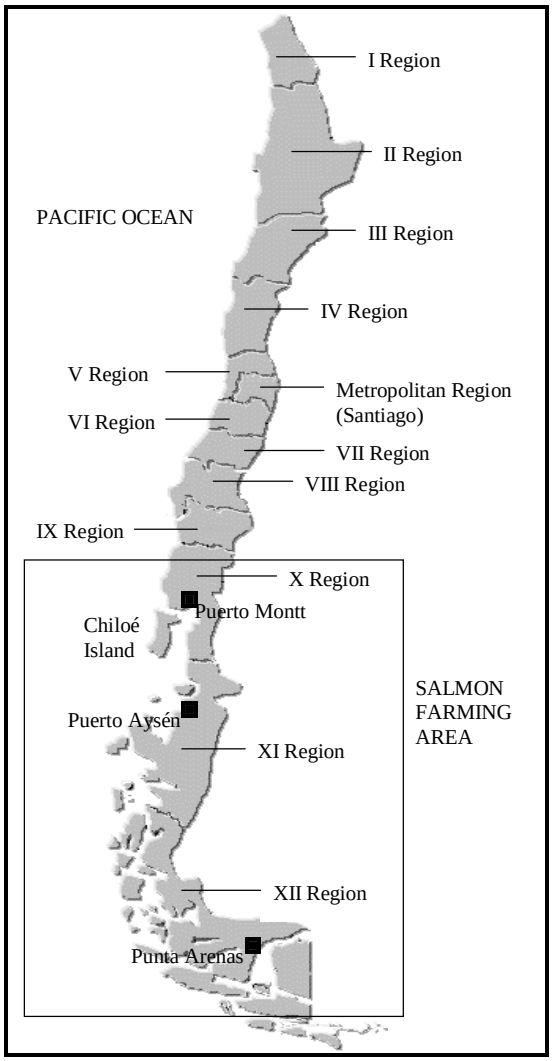


Figure 2. Map of Chile

The Chilean salmonid industry has expanded very rapidly from the mid 1980s. The production is concentrated on the three species coho salmon (*Oncorhynchus kisutch*), Atlantic salmon (*Salmo salar*) and salmon trout (*Oncorhynchus mykiss*). Annual harvests can be seen in table 1.

Table 1. Annual Chilean Harvest of Salmon and Trout 1985-2001 (tonnes)

	Atlantic	Coho	Others[a]	Total Salmon	Salmon Trout	Total Salmonid Production
1985		500		500	619	1,119
1986		1,144		1,144	1,007	2,151
1987	41	1,769		1,810	945	2,755
1988	165	4,040	3	4,208	1,267	5,475
1989	1,860	6,930	11	8,801	2,871	11,672
1990	9,478	13,298	345	23,121	5,481	28,602
1991	14,957	17,954	1,164	34,075	8,393	42,468
1992	23,715	22,165	735	46,615	15,515	62,130
1993	29,180	25,150	859	55,189	22,257	77,446
1994	34,175	34,524	379	69,078	32,866	101,944
1995	54,250	44,037	371	98,658	42,719	141,377
1996	77,327	66,988	341	144,656	54,429	199,085
1997	96,675	73,408	738	170,821	77,110	247,931
1998	107,066	76,954	108	184,128	75,108	259,236
1999	102,043	73,015	neg.	175,058	48,788	223,856
2000b	153,000	86,000	neg.	239,000	68,000	307,000
2001c	184,000	95,000	neg.	279,000	78,000	357,000

[a] Chinook and cherry.
[b] Preliminary.
[c] Estimate.
Neg.=negligible.
Sources:
1985-98: Bjorndal and Aarland (1999).
1999-2001: Industry sources.

From 1,119 tonnes recorded in 1985, the harvest was 259,000 tonnes in 1998, including salmon trout. This is equivalent to an average annual growth rate of 52% in total production. Coho was initially the predominant species. In 1992 it was surpassed by Atlantic salmon in production volume. Smaller quantities of chinook (*Oncoryynchus tschawytscha*) and cherry (*Oncorhynchus massou*) have also been farmed, but are of minor importance. The production of salmon trout has accelerated in the 1990s and surpassed the level of coho production in 1997.

Total salmonid production decreased from 1998 to 1999. This was due to the Asia crisis that hit Chile severely, as Japan is one of its main markets (cf. section 6). The decrease was particularly pronounced for salmon trout, where Japan is the dominant market. Subsequently production increased and total output is estimated at 357,000 tonnes in 2001. Salmon trout, however, has recovered slowly, with expected output in 2001 roughly equal to actual output in 1998.

As Chile is located in the southern hemisphere, its seasons are opposite to those of the northern hemisphere. Initially this provided a competitive advantage for the Chilean salmon farmers on the northern hemisphere fresh salmon markets as the off-season for the North American capture fishery (November to May) coincides with the coho harvesting season in Chile (January to March). Furthermore, in Chile maximum size is reached in the northern winter, a season when there is little growth in the northern hemisphere. The importance of this competitive advantage has been reduced as Atlantic salmon and salmon trout have gained importance in the Chilean salmonid industry. Atlantic salmon is harvested evenly throughout the year, while the harvest of salmon trout takes place mainly during the first and fourth quarters of the year. The fact that coho and salmon trout are predominantly exported frozen further weakens the importance of the opposite harvesting patterns compared with the northern hemisphere.

Egg imports.

Initially all salmon eggs were imported from abroad, and Chile still depends heavily on foreign suppliers (table 2). The total import of eggs was fairly stable from 1995 to 2000, except for 1998. However, the composition of imports changed. The imports of coho eggs have fallen significantly as local broodstocks were developed. Chile will become more or less self supplied with coho eggs in the near future. The imports of salmon trout eggs were reduced from 1995 to 1998, although with a recovery in 1999. On the other hand, imports of Atlantic salmon eggs increased throughout the period. The imports come from a limited number of countries. In 1999 European suppliers dominated for Atlantic salmon, while the US dominated for coho. For salmon trout, Denmark and the US were the major suppliers.

There has been serious concern that Chile is dependent on imports for an essential factor of production such as eggs. Furthermore, imported eggs may also bring diseases. As a consequence, stringent regulations of egg imports, requiring eggs to pass through quarantine facilities, were introduced in autumn 2000. The purpose of this is that Chile should become self sufficient in the production of eggs. It is still too early to tell how strictly the regulations will be enforced, and to what degree imports will be limited. However, as quarantine facilities currently have limited capacity, a likely consequence is that the expansion in salmon production may be slowed down in the near future until Chile becomes self sufficient in egg production. A likely consequence is also an increase in the cost of eggs and thus an increase in

cost of production. Nevertheless, Chile will still need to import genetics.

Table 2. Imports of Salmonid Eggs by Species 1995-2000 (Millions) and Major Suppliers 1999.

Species	1995	1996	1997	1998	1999	2000	Major Suppliers 1999
Atlantic	38.3	51.3	56.0	62.3	65.9	-	Ireland 33%, Norway 17%, Scotland 17%
Coho	3.2	1.9	2.0	1.5	1.3	-	US 100%
Chinook	2.7	0	0.5	-	-	-	-
Salmon Trout	57.2	57.2	54.4	27.1	42.6	-	Denmark 48%, USA 32%, Norway 13%
Total	101.4	110.4	112.9	90.9	109.8	113.4	

Source: *Aquanoticias Internacional.*

Regional Distribution of Industry.

As mentioned above, salmon farming in Chile is concentrated in Region X, but also extends into Regions XI and XII. Combined these regions represent a land area almost the size of Norway (table 3). However, regions XI and XII are very sparsely populated (table 3).

Table 3. Population as of 30/6/2000 and Land Area Regions X, XI and XII.

	Population	Land Area (Square km)
Region X	1 061 500	67,013
Region XI	95 000	108,494
Region XII	157 800	132,297

Source: Compendio Estadistico 2000, Instituto Nacional De Estadisticas.

The regional concentration of the industry can be seen in table 4, which gives the distribution of harvest by region for 1991-98. More than 85% of the production is concentrated in region X. This heavy concentration can partly be seen in light of the development of infrastructure in southern Chile. There is a railway connection and a good road to Puerto Montt, where there is also an airport. In contrast, the infrastructure farther south is quite poor except for the area around Punta Arenas in region XII. Good infrastructure is particularly crucial for the export of fresh salmon by air freight. This is confirmed by the fact

that nearly all the production of Atlantic salmon, which is exported fresh to the US market, takes place in region X.

While the share in total salmonid production of region X has been slowly declining since 1985, for region XI it has been increasing to 11.5% in 1998. This may be interpreted as a sign of available sites becoming scarce in region X, considering that regulation defines a minimum distance of 1.5 nautical miles between two fish farms and also sets out a division of the sea territory into separate areas for farming and fishing activities. (This situation might change should new technology permit the development of offshore sites in the Chileo basin.) Another motivation for salmon farmers to move south to region XI may be to reduce the risk of infections. However, as the tide is weaker farther south, the water flow is poorer. Although the sources of contagion are fewer, weaker tidal movements counteract this advantage and the final effect on disease patterns cannot be determined with certainty.

Table 4. Regional Distribution of Harvest 1991 and 1995-98

	1991	1995	1996	1997	1998
MR[a]	2.3 %	1.0 %	0.5 %	0.1 %	0.2 %
X	86.7 %	88.9 %	89.1 %	87.6 %	85.1 %
XI	9.3 %	8.0 %	9.1 %	10.6 %	11.5 %
XII	0.2 %	0.2 %	0.2 %	0.3 %	2.1 %

[a] Metropolitan Region (Greater Santiago); all kinds of trout are included, also fresh water rearing, which is located in this region. This is a minor industry, however, compared to the sea water trout farming.
Source: *Aquanoticias Internacional*.

A new dirt road recently opened between Puerto Montt and Puerto Aysén (Camino Austral). This has improved the accessibility of region XI. Still, poor infrastructure remains this region's main disadvantage compared to region X. Scattered population implies that supplies must be brought in. Also, transportation of feed and other inputs as well as the finished product is more expensive. The incentives for further expansion are therefore mixed and depend on provision of infrastructure locally and the site availability in region X.

Region XII accounts for 2.1% of the total harvest in 1998, as compared to 0.2-0.3% in previous years. Several factors contribute to this low participation rate in the salmonid industry. A major obstacle is the lack of infrastructure which prevails in most parts of the

region, except for Punta Arenas, where there is also an airport. Still, air freight is more expensive than from Puerto Montt. However, egg producers seem to be viewing Region XII as an attractive location because the average sea temperatures are lower than farther north. This would favour the growth of the alevins, and there may be reason to expect a growth in that segment of the salmonid industry in region XII.

3. INDUSTRY STRUCTURE

3.1. Institutional Framework

The Chilean aquaculture industry is regulated under the General Law of Fisheries and Aquaculture from 1991. The General Law sets about four main areas of regulation:

1) Regulations applicable to the import of hydrobiological species.

2) Regulations applicable to applications for and transfer of aquaculture concessions and authorisations.

3) Regulation applicable to the operation of aquaculture concessions or authorisations.

4) Regulations applicable to ocean ranching.

The regulatory responsibility lies with the Undersecretariat of Fisheries (Subsecretaría de Pesca), while the National Fisheries Service (Servicio Nacional de Pesca, Sernapesca) exercises the control with law compliance. Both institutions are parts of the Ministry of Economy, Development and Reconstruction. Subsecretaría de Pesca is also responsible for the determination of Appropriate Areas for Aquaculture (AAA).

The number of salmon farming licences 1998-2000 is given in table 5. A licence consists of an aquaculture authorisation together with a licence for farming activities. It corresponds to the complete water column from the surface area to the bottom, both inclusive. The licence is given for indefinite time, and the owner has the right to sell it or rent it. Together with the application for a concession a five year development plan must be submitted. If the concessionaire has not achieved at least 50% of the proposed activities after the first year, the concession may be reduced by the authorities. A nominal fee is paid for licences.

Table 5. Number of Salmon Farming Licences Chile 1998-2000.

Year	Number
1998	345
1999	362
2000	435*

*Preliminary.
Source: Subsecretaria de Pesca.

There has been a sharp increase in the number of applications during the last years. Criticism has arisen from the industry that the bureaucracy impedes the growth of Chilean salmon aquaculture as a high number of institutions participate in the decision process. In addition to Subsecretaría de Pesca and Sernapesca, the applications must be approved by the Undersecretariat of the Navy (Subsecretaría de Marina) and several divisions of the National Environmental Commission (Comisión Nacional del Medio Ambiente, Conama). Since 1997, there has been a mandatory environmental impact study, administered by the National Environmental Commission, for all licence applications for sea farming activities. Apparently, approving a new licence requires the approval of 17 different authorities. The process of awarding licences is therefore time consuming and has created long backlogs. The new minister of fisheries as of year 2000 has stated that the process will be simplified and expedited.

Except for the matter of licences, Chile has few regulations of its salmon aquaculture industry compared to Norway.

3.2. Industry structure

There is a strong tendency towards vertical integration in the production of salmonids. Even minor producers will process, market and export their own production. The degree of vertical and horizontal integration has been increased. The amount of foreign investments in the industry has also increased. It is, however, anticipated that Chilean firms may also make investments abroad. Furthermore, it is common to rear two or three salmon species as opposed to only one in order to spread the risk, both on more species and on more markets. This also contributes to a smoother harvesting pattern, and consequently cash flow, throughout the year. Capacity can also be utilised more evenly.

Table 6 gives the number of firms and average firm size in tonnes 1992-99. While the

number of firms has decreased, average size has increased from 790 tonnes in 1992 to 5,447 tonnes in 1999. Combining the information in table 6 with that of table 5, it can be inferred that, in 1999, the average firm had nine licences with an average output of about 600 tonnes per licence. This indicates an output per licence roughly comparable to what is found in Norway.

Table 6. Number of Farming Firms and Average Firm Size (Tonnes), 1992-99.

Year	No. of Firms	Average Size (Tonnes)
1992	63	790
1993	60	1,102
1994	58	1,315
1995	56	1,745
1996	55	2,460
1997	48	3,336
1998	45	4,036
1999*	40	5,447

*Estimate. Source: Norheim (2000).

Data on exports by individual companies are available on an annual basis. These have been used to find the degree of concentration in Chilean salmon exports for 1990-97 as presented in table 7. Chilean salmonid production expanded tremendously as was shown in table 1. At the same time there was substantial entry to the industry, especially from 1990 to 1994. In this period with very rapid expansion, the largest exporters were not able to maintain their market share. However, the medium sized companies (the group from the 6th to the 20th largest exporters) increased their market share from 28% to 36%. For the smallest companies their joint share increased from 22% to 36%, but as the number of companies in this category more than doubled, their average individual share was reduced from 1990 to 1994. From 1994 to 1997 the shares of the largest exporters remained more or less unchanged. A simultaneous increase in the number of exporters by 17% indicates a further reduction in the average share in exports for the smallest companies from 1994 to 1997. According to industry sources, the degree of concentration in exports has been increasing after 1997.

Table 7. Concentration in Salmon Exports and Number of Exporters in 1990, 1994 and 1997

	Share in Salmon Exports (Value)		
	1990	1994	1997
Largest five exporters	50%	26%	26%
Largest 10 exporters	64%	43%	43%
Largest 20 exporters	78%	64%	65%
Number of exporters	83	187	219

Source: Bjorndal and Aarland (1999).

Table 8 gives a list of the 10 largest firms in the Chilean salmon aquaculture industry. The table contains information about production (Atlantic salmon, coho and salmon trout) for 2000 as well as expected output for 2001 and turnover for 2000. The firms included in the table represent about 47% of Chilean production in 2000. This may also indicate an increased degree of concentration in the industry after 1997, as suggested above.

Table 8: The 10 Largest Firms in the Chilean Salmon Aquaculture Industry 2000.

Firm	Prod. 2000 (tonnes)	Expected prod. 2001 (tonnes)	Turnover 2000 (mill. NOK).
1. Salmones Pacifico Sur S.A.	27 000	50 000	620
2. Camanchaca S.A.	19 000	25 000	630
3. Multiexport S.A.	18 000	25 000	765
4. Salmones Unimarc S.A.	16 000	18 000	450
5. Trusal S.A.	12 000	16 000	-
6. Invertec	11 000	20 000	1 260
7. Cultivos Marinos Chiloé	11 000	15 000	450
8. Aguas Claras S.A.	11 000	13 000	387
9. Salmones Antartica S.A.	11 000	13 000	270
10. Los Fiordos (Ch)	10 000	16 000	-

Source: IntraFish.

The feed market is dominated by two multinational companies, Ewos (Statkorn) and Trouw (Nutreco). These two companies have a combined market share of 77% (Norheim,

2000). The rest of the market is composed of three local producers.

3.3 Research and Development

Crucial areas for future sustainability of the industry are in particular disease patterns and preservation of the naturally favourable environmental conditions. The Chilean salmonid industry has developed without major setbacks due to diseases, but there is currently a growing concern for diseases such as rickettsia and sea lice, especially in densely farmed areas of region X. Still, improvement can be achieved from realising improved management practises. Finally, it is expected that the future growth of the salmonid industry will be mainly demand driven (Barton, 1998). Consumer awareness is on the rise and people become more and more concerned with the quality of the food they eat. A preference for minimal medication has also emerged.

A partly related problem is the risk of environmental degradation. Currently there is lack of transparency in the industry regarding use of medication and other chemical inputs and little public debate on these concerns. Absence of monitoring mechanisms complicates the introduction of industry standards.

Research is conducted in both public and private institutions. Various universities conduct research on salmon farming, the major ones being Universidad de Chile (Santiago), Universidad Austral (Valdivia) and Universidad de los Lagos (Osorno).

The Fisheries Development Institute (Instituto de Fomento Pesquero, IFOP) is the major fisheries research institute in Chile. It is based in Valparaíso, but has a division for aquaculture in Puerto Montt. IFOP is an independent institution, but resides within the Economic Development Corporation (Corporación de Fomento de la Producción, CORFO) and is also closely linked with the Subsecretaría de Pesca. Salmon research has been concentrated on the development of coho eggs and local coho broodstocks in addition to ichthyology. IFOP has also very much been involved with the diversification of the Chilean aquaculture, actively promoting the introduction of new species into the industry.

The Salmon Technology Institute (Instituto Tecnológico del Salmón, Intesal) was established by the Association of Salmon and Trout Producers in Chile (APSTCH) in 1993 with financial assistance from CORFO. It undertakes salmon research on environmental impacts and diseases.

Fundación Chile is a private non-profit research institution with substantial effort in the

areas of agriculture, aquaculture and forest management. Primary focus is on technological innovation and transfer. Fundación Chile was one of the driving forces in aquaculture during the late 1980s and set up several pioneering companies in smoltification and salmon farming. Some major salmon farms were initiated by Fundación Chile, for example Salmones Antártica S.A., Salmones Huillinco S.A. and Salmontec S.A., but have all been sold off to private owners. Today the main focus is on the introduction of new species into the aquaculture industry. Current salmon research is concentrated on nutrition and diseases and is carried out in the three laboratories located in Santiago, Puerto Montt and Castro (Chiloé) and at the research station just outside Puerto Montt.

4. COST OF PRODUCTION

Cost of production data in salmon aquaculture are collected annually by the government of Norway. For this reason, good data are available over a long time period, facilitating various kinds of analysis. The situation is the opposite for Chile, where there is no systematic collection of cost data, as these tend to be treated as confidential.

Cost data for Atlantic salmon, farmed in Chile, for year 2000 are given in Table 9. Corresponding numbers from Norwegian rearing of Atlantic salmon will be presented in table 10. All values are nominal.

Table 9 gives cost of production for Atlantic salmon for year 2000. The cost data come from one of the larger firms in the industry with a number of different sites. It is, however, difficult to tell how representative they are for the industry at large. Costs are classified according to technology; high technology and low technology centres. For each category minimum and maximum costs are given. For low technology centres, costs vary between $1.73-1.78, for high technology centres they vary between $1.35-1.60. Differences in feed costs represent the main difference between the two technologies. High technology centres use automatic feeders. As a consequence, the feed factor may be reduced. Moreover, pigmentation and labour are also lower, presumably also due to automation.

Table 9. Cost of Production Atlantic Salmon Chile 2000 US$/kg Round Weight.

	Low technology centres		High technology centres	
	Minimum	Maximum	Minimum	Maximum
Smolt	0.29	0.29	0.27	0.40
Feed	0.76	0.91	0.69	0.78
Pigmentation	0.21	0.23	0.16	0.19
Medication	0.02	0.02	0.01	0.02
Transport	0.01	0.02	0.01	0.02
Labour	0.10	0.06	0.04	0.03
Var. costs	1.39	1.53	1.20	1.44
Depreciation	0.08	0.05	0.03	0.03
Adm.costs	0.05	0.05	0.03	0.03
Cost of prod.	1.73	1.78	1.35	1.60

Note: Transport refers to transportation of smolts and feed.
Source: Norheim (2001).

Bjorndal and Aarland (1999) analysed cost of production in Chilean salmon aquaculture, based on data for 1997. The 1997 and 2000 data come from different sources and again, it is difficult to know how representative the data are, as Notwithstanding this, when comparing the data for Atlantic salmon, cost of production is lower in 2000 and in 1997. It appears that, in particular, feed and labour costs have been reduced.

Table 10 presents production costs for Norwegian Atlantic salmon for the period 1995-99. In general, production costs for Atlantic salmon have been declining more or less continuously since the mid 1980s (Bjørndal, Tveterås and Asche, 1999). The survey emphasises two key figures. Operating costs per kilo round weight are comprised of smolt costs, feed, wages, net capital cost, insurance and miscellaneous. They amounted to USD 2.135/kilo in 1999. Cost per kilo salmon delivered from the plant further includes depreciation, freight to plant, slaughter costs and packaging and, up to 1998, compensations, bad debts, estimated owner's wage and return to equity. In 1999 the cost per kilo salmon out of the plant was equal to USD 2.55/kilo.

Table 10. Production Cost of Norwegian Atlantic Salmon 1995-99 in USD/kg Round Weight

Type of Cost	1995	1996	1997	1998	1999[b]
Operating Costs NOK/kg	18.73	17.20	16.95	17.17	16.65
Cost ex. Plant NOK/kg	21.67	20.28	20.22	20.03	19.88
Exchange Rate[a]	6.34	6.46	7.08	7.54	7.80
Smolt	0.593	0.464	0.380	0.296	0.324
Feed	1.450	1.331	1.287	1.288	1.105
Wages	0.293	0.257	0.227	0.214	0.191
Net Capital Cost	0.153	0.136	0.105	0.102	0.112
Insurance	0.063	0.054	0.034	0.033	0.036
Other Costs	0.402	0.421	0.362	0.344	0.365
Operating Costs per kilo	2.954	2.663	2.394	2.277	2.135
Compensations(-)	0.028	0.011	0.017	0.031	
Bad Debts	0.008	-0.002	0.004	0.003	
Estimated Owner's Wage	0.002	0.002	0.001	0.000	
Return to Equity	0.076	0.067	0.048	0.045	
Depreciation	0.052	0.088	0.083	0.089	0.085
Freight to Plant	0.039	0.028			
Slaughter/Packaging[c]	0.315	0.305	0.342	0.292	0.328
Cost ex. Plant	3.418	3.139	2.856	2.656	2.549

[a] The exchange rate is the official annual average rate obtained from The Central Bank of Norway

[b] Due to a new accounting law, compensations, bad debts, estimated owner's wage and return on equity are no longer considered part of cost of production. In 1998, these items accounted for $ 0.079.

[c] Freight, slaughter and packaging costs have been combined since 1997.

Source: Norwegian Directorate of Fisheries

The costs figures in table 10 have been converted into USD in accordance with the official average annual exchange rate for the purpose of comparing them with the Chilean figures. The key figures are also stated in Norwegian Kroner. The exchange rate influences the production costs expressed in USD. The average annual exchange rate varies between NOK 6.34 and 7.80 per USD in the period. A weak Norwegian Krone will deflate the costs, while a stronger Norwegian Krone will inflate them when converting to USD. For instance, the reduction in operating costs stated in NOK was 1.5% from 1996 to 1997, while it equalled 10% when converted into USD.

Leaving the slaughter and packaging costs out, all costs are given per kilo round weight. The relevant production costs which will be compared are thereby USD 1.35-1.78/kg for Chile (Table 9) and USD 2.22/kg for Norway (Table 10). This states that production costs are 44-87 cents higher per kilo in Norway than in Chile. In all likelihood, this is an exaggeration. Cost data for Chile do not include capital costs, other than depreciation, and

"other costs". For Norway, these categories amount to 56 cents, effectively eliminating the cost differential between the two countries.

Chilean competitive advantage in salmon farming has normally been attributed to relatively cheap feed based on locally produced fish meal and low wages. Regarding feed cost, table 9 shows that feed cost per kilo Atlantic salmon vary between USD 0.86-1.16 in Chile when pigmentation and medication are included, compared to USD 1.105/kg in Norway. This indicates a certain cost advantage for Chilean producers. There are two components in the feed cost: feed price and feed conversion ratios. The feed cost figures do not give details on these aspects and therefore the exact nature of the Chilean cost advantage cannot be further examined.

Labour costs appear to be substantially lower in Chile than in Norway. In all likelihood, these numbers exaggerate the difference. While Table 9 only includes labour at the farm site, table 10 also includes farm management. Bjorndal and Aarland (1999) compared labour costs in Chile and Norway based on cost data for 1997, and found that the Norwegian fish farmer spent only 10% more than his Chilean counterpart, which is quite low considering the fact that the average wage for people employed at sites is far higher in Norway than in Chile. There are, however, much larger differences in wages in Chile than in Norway. While unskilled labour may still be cheap, there may be smaller discrepancies in the cost of operational staff and management. Furthermore, labour costs have been targeted by Norwegian producers in order to reduce production costs. More efficient work routines and a higher degree of mechanisation in Norway may therefore be contributing factors.

With regards to smolt costs, the Chilean producer spends USD 0.27-0.40/kg on buying smolt and transporting them to the site, while the Norwegian farmer spends USD 0.324/kg.

Generally, there may be more room for further cost reductions in Chile than in Norway. The Norwegian salmon industry is more mature, and being situated in a high-cost country, cost reductions have been a major concern as the international competition has increased. Chile has benefited from low labour cost and local production of fish meal. However, these competitive advantages seem to have diminished. Industry sources cite logistics as an area for further efficiency gains. The prevailing lack of infrastructure in region XI and XII has been commented upon. Future expansion of the industry may to an important degree take place in these regions. Although farming conditions are favourable, the general

lack of infrastucture will be the source of higher investment costs and to some extent, higher variable costs such as transportation and labour. Furthermore, inefficiencies due to loading and unloading exist. Today most feed factories are located inland, and the feed must therefore be brought to the shore side on trucks and loaded onto boats to be brought out to the farm sites, as many fish farms do not have road access. The reverse procedure is carried out for the reared salmonids to go to the market. Key facilities are scarce and expensive to construct due to large tidal differences, and beaches are therefore in many cases used for landing purposes. Improving these structural characteristics will most likely be an expensive and slow process, taking place as capital gradually wears out.

Another issue is the high mortality in the different stages of salmonid production. Also, cost of production will be influenced by future disease patterns and the industry's ability to find preventive or curative medication. Intensive farming in sheltered areas and lack of universal standards for environmental conservation and "good husbandry" may prove detrimental to the Chilean salmonid industry in case of a major disease outbreak.

Fish theft is a phenomenon particular to Chile. The salmonid industry is centred in regions X, XI and XII, which have traditionally belonged to the economically depressed areas of Chile. The rise of the salmonid industry has generated employment in these areas, but it has also led to tension between salmon farmers and traditional fishermen. Fish stocks have in general declined in southern Chile, and catches have been reduced for local fishermen. It has therefore been a tempting option to set out nets in order to catch cage escapees from the fish farms, or even to provoke such escapes. So far fishing for cage escapees has been illegal, and the Association of Salmon and Trout Producers has struggled hard to keep this prohibition such that the incentive for fish theft is minimised.

Some other considerations are in order. Hitherto, smolt production in Chile has largely taken place in fresh water lakes, a production system that necessitates rather modest investments as compared to land based facilities used in Norway. As available fresh water sites have become exhausted, further expansion will likely occur in land based facilities. Although this is the same technology as in Norway, it may increase the cost of producing smolts.

As pointed out in Section 2, Chile is not self sufficient in egg production, and restrictions on the imports of eggs were introduced in 2000. This is likely to increase egg costs, certainly in the short to medium turn, as the industry expands output in order to replace imports.

5. MARKETS FOR SALMON

Chile has a limited domestic market with its nearly 15 million inhabitants, who do not have a strong record of fish consumption. The Chilean salmon industry has therefore been an export oriented industry from its beginning (table 11). Naturally, the export patterns are the same as for the production. Coho was the most important species until 1992, when it was surpassed by Atlantic salmon. In 1997 the exported quantity of salmon trout was also higher than that of coho. Comparing these numbers to the production numbers given in table 1, we find a considerable and growing discrepancy between production and exports. This reflects the fact that steadily more value adding takes place in Chile prior to exports, and the share of processed products in exports has increased every year.

Table 11. Total Chilean Exports of Salmonids by Species 1987-00 (Tonnes)[a]

	Atlantic	Coho	Salmon Trout	Total
1987	3.2	1,014.0	661.5	1,678.7
1988	61.9	3,105.2	883.1	4,050.2
1989	1,485.3	4,896.9	1,759.5	8,160.8
1990	8,392.4	11,676.0	4,043.5	24,286.2
1991	12,497.7	14,287.7	5,452.6	32,939.2
1992	19,964.1	17,565.0	11,092.6	49,871.7
1993	24,846.0	17,982.4	12,296.4	60,752.5
1994	26,793.6	24,757.0	15,803.5	76,545.8
1995	39,366.3	30,946.5	22,919.5	97,832.0
1996	53,838.0	42,982.0	35,831.8	134,292.8
1997	64,740.3	44,112.3	47,700.5	160,327.6
1998	67,336.0	57,190.0	56,958.0	181,614.0
1999	63,620.8	56,560.3	34,650.4	154,904.0
2000	94,589.0	64,394.0	46,573.0	206,254.0

[a] The weight refers to the weight of the exported products, and not round weight. These numbers are therefore not directly comparable with the production volumes given in table 2.

Sources: IFOP (1987-1997)
Asociaciòn de Productores de Salmòn y Trucha de Chile (1998-1999).
Aquanoticias (2000).

The main markets for Chilean salmon and trout are the US and Japan (Tables 13-15), representing 36.7% and 49%, respectively, of Chilean salmonid exports in 2000. Initially, coho was exported fresh to the US. Since 1989 coho has mainly been exported frozen, and Japan has taken over as the principal buyer. Atlantic salmon, on the other hand, is mostly

exported fresh, with the US as the major market. Salmon trout is mainly exported frozen, also with Japan as the dominating market.

The extreme dependency on the US and Japanese markets makes the Chilean exporters vulnerable to international economic trends and trade policies. Exporters of coho and salmon trout were greatly affected by the Japanese crisis, while exporters of Atlantic salmon have faced dumping charges from the US in 1998. The Asia crisis actually led to a reduction in output as well as reduced exports in 1999.

Chilean exporters have tried to develop new markets in recent years to reduce their dependency on Japan and the US. For coho and trout, there is effectively only one market, Japan, which may be levelling off. Increased production will be mainly for Atlantic salmon. The US market has potential for further growth. Also Latin America, where Brazil has evolved as the most important market for Atlantic salmon, has potential. Attempts to gain market share in the European market have still not proven successful.

Chilean samonid exports to Brazil are given in table 12. Exports increased for virtually nothing in 1993 to 7,657 tonnes in 2000, representing 2.8 % of Chilean salmon exports. Although still representing a small fraction of Chilean exports, the relative increase in exports has been substantial over the past few years. Quantitywise Brazil has also gained importance.

Table 12. Chilean Salmon Exports to Brazil 1993-2000 (Tonnes).

Year	Quantity
1993	Neg.
……	
2000	7,656.8

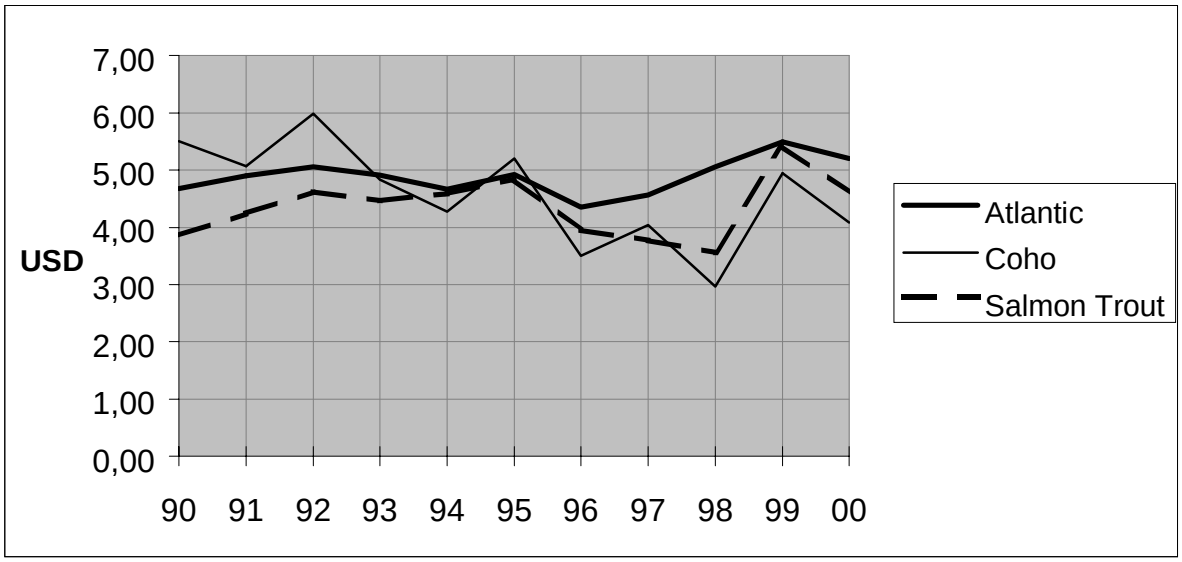
Neg.=negligible.

Source: Bjorndal and Aarland for 1993,
Aquanoticias for 2000.

The average price obtained for the exported quantities from 1990-2000 can be seen in figure 3. The prices refer to FOB Chile, i.e., an average from the different shipping ports. The prices are average prices for the three species. As such, they also reflect the compostion of exports, i.e., different product groups. As this has changed over time, it is difficult to interpret how representative the prices are. Nevertheless, over time the prices have converged. The average price of coho has been more volatile than the other two with frequent falls and rises.

Prices of coho and salmon trout fell 1995-98, while the price of Atlantic salmon showed less variation. In 1999 prices increased and once more converged.

With the exception of Japan and partly Scotland, all producers of farmed salmon are geared towards export markets. Transportation costs will therefore have a major impact on a country's competitiveness. Expansion into the new markets like the European presupposes reliable and reasonable transportation. The Chilean Atlantic fillets hold high standards and may even with the current tariffs into the EU be competitive, but transportation costs are imperative, and volume is required for freight rates to fall. Today there are airports in Puerto Montt (region X) and Punta Arenas (region XII). For salmonid farmers in region XI this implies long transportation over land before salmon can be exported.



Source: Infopesca.

Figure 3. Average Nominal FOB Price by Species 1990-2000, USD/kg

The cost of air freight to the US is about $ 1.08-1.18, to Europe about $ 1.80 and to Japan $ 2.80-3.20 (Norheim, 2000). A problem is that the market for airfreight is dominated by one agent, Lan Chile. Furthermore, expanding air freight capacity appears as a problem. Thus, the scope for reduced freight rates appears limited. A number of airlines, including British Airways and KLM, have recently discontinued flights to Santiago. This contributes to enhancing the position of the dominant supplier in the market for airfreight, Lan Chile.

The United States Market.

Salmon exports from Chile to the US in 2000 were 65,000 tonnes at a value of US $ 358.2 mill. This represented 36.7% of Chilean salmonid exports. Salmon imports to the US market for 1995-99 is given in Table 13. Import of whole Atlantic salmon increased from 41,708 tonnes in 1995 to 56,385 tonnes in 1999, an increase of 35 %. Chile is the main supplier of this product form. However, the six-fold increase in imports of fillets, from 9,931 tonnes in 1995 to 55,006 tonnes in 1999, is truly remarkable. Of the 1999 quantity, 85 % was fresh.

Table 13. Salmon Imports to the US Market 1995-99, Tonnes Product Weight.

	1995	1996	1997	1998	1999
WHOLE					
Atlantic salmon	41,708	50,632	55,580	54,962	56,385
Other	15,501	13,896	18,267	14,062	19,025
FILLETS					
Fresh	7,359	13,489	24,065	41,883	46,871
Frozen	1,816	3,561	6,308	5,283	6,591
Unspecified	756	0	0	3,946	1,594
Total	9,931	17,050	30,373	51,112	55,056

Source: National Marine Fisheries Service.

Imports from the three main suppliers for 1996-99 is given in Table 14. In 1996, Chile dominated this market. Up to 1999, Chilean supply increased to three times the 1996 level. What is truly remarkable, however, is increased supply from Canada and, in particular, Norway.

Table 14. Imports of Salmon Filets to the US Market 1996-99, Tonnes

	1996	1997	1998	1999
Chile	13,817	24,723	41,538	38,192
Canada	471	3,316	5,056	5,534
Norway	366	781	1,537	6,764

Source: National Marine Fisheries Service.

The North American Free Trade Agreement (NAFTA) between Canada and the United States was implemented in January 1989. Later, Mexico also joined NAFTA. Being outside the NAFTA agreement, major salmon producers are vulnerable to protectionist measures, which would clearly favour Canadian and US producers. In 1991 Norwegian salmon farmers were accused of dumping and receiving government subsidies, and an average tariff of 26% was levied on all Norwegian salmon entering the US market. This effectively barred Norwegian producers from this market. The market was partly overtaken by Chilean producers. However, Chilean producers have also been accused of dumping and receiving government subsidies.

In June 1997 eight salmon producers from Maine and Washington placed allegations against Chilean exporters of all forms of fresh Atlantic salmon to the US market. The accusations included receiving subsidies from the Chilean national treasury, as well as practising dumping on the US market. The claim from the local salmon producers was that all fresh Atlantic salmon imported from Chile be subject to a 42% tariff. A preliminary decision made public by the US Department of Commerce in November 1997 concluded that the publicly sponsored programmes of technological assistance provided to the Chilean salmon industry amounted to only 0.62% of the total value of the exports, which was under the 2% level considered by the World Trade Organisation as a minimum for applying trade sanctions. This decision, stating that Chilean salmon producers had not been subsidised, was ratified in April 1998, but further investigations followed to decide whether Chilean exporters of fresh Atlantic salmon were practising dumping on the US market. On the basis of auditing of Chilean salmon producers, the US Department of Commerce and the US International Trade Commission, found some producers to be selling their products below the equivalent price charged in other markets. While some companies are levied no duty, others are levied an average duty of 4.54%.

Although significantly lower than the initial claim of 42%, the tariffs imposed have been perceived as unfair by Chilean salmon producers, who insist that the government has not granted them any subsidies, nor have they practised dumping. They claim their success in the North American market is purely a result of comparative advantages in production together with successful marketing efforts. On this basis the Association of Salmon and Trout Producers in Chile has appealed the dumping verdict, and it remains to be seen whether it will be altered. The verdict may have an important signalling effect, inciting Chilean salmon

producers to increase efforts in other markets such as Latin America and Europe.

The Japanese Market

Japan is the world's largest fish market and the most important market for Chilean salmonids. Estimated consumption of salmon and trout in 1997 was around 500,000 tonnes, of which nearly half is imported (Bjorndal and Aarland, 1999). Prices have fallen as the market has become saturated. The scope for further expansion appears limited (Nakamoto, 2000).

Table 15. Salmon Imports to the Japanese Market 1994-99, Tonnes Product Weight.

	1994	1995	1996	1997	1998	1999
SALMON						
TROUT						
Norway	7,453	7,569	11,426	16,244	17,685	30,268
Rest Scandi-						
navia	2,489	989	1,831	1,147	1,093	6,579
Chile	17,350	19,485	22,592	31,303	40,508	25,264
TOTAL	28,557	30,476	36,472	50,332	59,691	63,444
COHO						
Chile	23,112	29,832	38,010	43,588	49,553	47,397
TOTAL	39,223	41,265	47,642	47,082	56,215	53,765
ATLANTIC						
SALMON						
Norway	3,163	5,297	7,204	5,078	4,531	14,362
Chile	1,187	1,373	1,314	1,843	1,349	1,103
Others	241	715	411	118	32	307
TOTAL	4,591	7,385	8,929	7,039	5,912	15,777

The Japanese prefer sockeye for its reddish meat, while locally produced chum and coho follow next. Also the demand for salmon trout has increased rapidly. Initially wild caught salmon from Canada and the US covered the imported consumption. Over time farmed salmon and salmon trout from Chile and Norway, in addition to wild caught salmon from Russia, have gained increasing shares on the Japanese market. Chile is today the main foreign supplier of

salmon and salmon trout. The main advantage for farmed Chilean salmonids is its availability during the part of the year when supply of wild salmon is scarce. In addition, Chilean coho and salmon trout supplies are smoothened by the fact that the bulk of the exports to Japan are frozen.

Exports of salmon and salmon trout from Chile to the Japan in 2000 were 111,000 tonnes at a value of US $ 477.1 mill. This represented 49 % of Chilean salmonid exports. Table 15 gives imports of salmon trout, coho and Atlantic salmon to Japan, 1994-99. Imports of salmon trout more than doubled from 28,557 tonnes in 1994 to 63,444 tonnes in 1999. Up to 1998, Chile was the main supplier. In 1999, however, imports from Chile declined, while they increased from Norway which that year was the main supplier. Imports of coho increased from 39,223 tonnes in 1994 to 53,765 tonnes in 1999. The market share of Chile was 88% in 1999. Imports of Atlantic salmon increased from 4,591 tonnes in 1994 to 15,777 tonnes in 1999. Norway is the dominant agent in this market segment.

6. THE COMPETITIVENESS OF THE CHILEAN SALMON AQUACULTURE INDUSTRY

In its brief industry, the Chilean salmon industry has exhibited substantial expansion. As in other countries, this has been achieved by producing more at each site, but also by increasing the number of sites (table 5). Table 16 gives the forecasted number of farming licences in Chile until 2010. From 435 licences in 2000, the number is expected to increase to 1,200 in 2010, an almost three-fold increase in a decade.

It may be questioned whether this increase will actually be achieved, keeping in mind the bureaucratic obstacles that need to be overcome before a licence can be issued. Nevertheless, it is also a fact that there is political will to expedite the process and to achieve the kind of expansion indicated by Table 16. In other words, it is very likely that there will be a substantial expansion in the number of farming licences in the years to come.

Table 16. Forecasted Number of Salmon Farming Licences Chile 2000-2010.

Year	Number
2000	435*
2005	770
2010	1,200

*Preliminary.
Source: Subsecretaria de Pesca, private communication.

It was stated above that the Chilean industry may have greater potential for efficiency improvements than the Norwegian (Section 4). On the other hand, there are also a number of disadvantages. Egg and smolt production may occur at a higher cost than in the past. Investments in infrastructure in Regions XI may be substantial. This may lead to an increase in cost of production, also because some variable costs (transportation, labour, supplies) may increase. Chile is behind Norway in terms of research and development, relating to most, if not all areas of the industry. New technology is to a large degree imported, with Norway a major supplier.

Salmon aquaculture is an export industry for both Norway and Chile. Even if Norway has faced and does face trade problems in Europe, the geographical proximity of the market, permitting delivery of fresh product by road transportation, is a great advantage. Chile does not have a comparable "home" market; both Japan and the United States are "overseas" markets. In the foreseeable future, Latin America, although growing in volume, cannot match the importance of any one of these two markets.

On the other hand, Chile has achieved a greater degree of further processing of salmonids than is the case for Norway. High tariffs on Norwegian exports of processed products to the EU may be one reason for this, but not the only one. Although labour costs may not be an important cost advantage for Chile in salmon farming, they probably are when it comes to fish processing. An indication of this is the substantial export from Chile of fresh fillets to the United States. Measured in round weight, the export of fillets to the United States is larger than the export of whole fish. In this sense, the degree of processing is higher in Chile than in Norway.

The obstacles involved in obtaining licences in Chile were discussed in Section 4. Apart from this, there are few regulations of the industry in Chile. This is very different from Norway, where the industry has been heavily regulated throughout its brief industry, although

the rationale for imposing regulations may have changed over time. In many ways, it is very particular that so many regulations have been imposed on an export industry as is the case in Norway. The recent proposal in Norway to limit the number of licences per firm would be unheard of in Chile. From a commercial perspective, there is no doubt that it is advantages to operate in a more liberal business environment such as the one found in Chile.

Both the Chilean and Norwegian industries are in principle able to expand production substantially. When comparing the competitiveness of the two countries, on the basis of the discussion above, there is no reason to expect that Chile will improve its competitiveness vis-à-vis the Norwegian industry, at least not in the foreseeable future. For the same reasons, there is no reason to expect that Chilean salmon will make substantial inroads in the European market, unless terms of trade are changed by new trade barriers.

Providing estimates of future growth in the salmon aquaculture industry has in the past proved to be a rather inexact science. Due to the reasons discussed above, it is indeed difficult to provide estimates with regard to the future growth of the Chilean industry. Furthermore, future growth may be market constrained, i.e., it will also depend on what quantities the different markets will accept at different prices. Notwithstanding these difficulties, an average annual growth rate for the Chilean industry can be expected to be in the range 20-30 %. This is lower than the historical average, which is reasonable as the industry is maturing. On the other hand, it represents a growth rate that can be matched by only few other industries.

7. CONCLUSIONS

The Chilean salmonid industry has evolved as a main player in the international markets for salmon and trout. From its beginning in the early 1980s the industry has expanded at an impressive rate to an estimated output in 2001 around 360,000 tonnes of salmonids. The major contributing factors to its success have been the naturally favourable environmental conditions for salmonid farming in addition to available risk capital, low labour cost and local provision of fish meal. Also, the government has pursued a policy of minimum intervention and has placed few constraints on the expansion of the industry as it has boosted economic activity in formerly depressed regions and become a major generator of foreign currency.

It has been stated that future growth of the salmon industry world wide will be largely

demand driven. Prices fetched have declined as the markets have saturated, and cost efficiency has become a major imperative for international competitiveness. As the comparison between Chilean and Norwegian industries indicated, there is not reason to believe that Chile will improve its competitiveness compared to Norway in the short to middle term.

Major future challenges to the Chilean salmonid industry will include developing new markets for farmed salmon and trout in order to make the industry less dependent on economic conditions in its major export markets. Trade disputes with local salmon suppliers in the US and the economic crisis in Japan have proven Chile's vulnerability regarding their two main markets. Another major concern arising in recent years has been the preservation of the naturally favourable environment for farming of salmonid species in Chile. Critics have called for more government intervention in order to ensure the sustainability of the industry, but the industry itself has favoured self-imposed regulation. Spared of massive disease outbreaks so far, preventive measures have yet to be agreed on and implemented universally.

APPENDIX: PRICE DATA.

Table A1. Export Prices by Species 1990-2000, USD/kg.

	Atlantic	Coho	Salmon Trout
1990	4.674	5.500	3.861
1991	4.904	5.064	4.239
1992	5.062	5.988	4.617
1993	4.909	4.837	4.470
1994	4.667	4.278	4.592
1995	4.917	5.199	4.842
1996	4.355	3.504	3.952
1997	4.562	4.035	3.769
1998	5.052	2.970	3.563
1999	5.497	4.945	5.422
2000	5.202	4.084	4.609

Source: INFOPESCA.

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