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The Salmon Disease Crisis in Chile

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Abstract *The Chilean salmon farming industry is currently facing unprecedented economic losses related to the infectious salmon anemia (ISA) disease. Production of Atlantic salmon is being reduced from almost 400,000 tonnes in 2005 to an estimated 100,000 tonnes in 2010. The spread of and response to the disease raises a number of important issues with respect to the actions of the companies involved as well as the regulatory body. It is particularly interesting that adequate measures have not been implemented in Chile, as the species is farmed in relatively few countries and, as such, is fairly transparent. Moreover, all other major salmon- producing countries have experienced the disease, and several of the largest companies in Chile are multinationals with first-hand experience with ISA from other countries.*

Key words Salmon, disease, regulations.

JEL Classification Codes K32, Q22.

Introduction

Currently, the Chilean salmon aquaculture industry is experiencing the worst disease outbreak ever observed in salmon aquaculture and, in terms of revenue losses, possibly in all aquaculture so far. In 2007, the world's largest salmon-producing company, Marine Harvest, reported that they had discovered infectious salmon anemia (ISA) at a farm producing Atlantic salmon in Chile. This was the first report of the disease in Chile. However, reports of new outbreaks have increased rapidly since then, and industry sources are now indicating that in 2009 the smolt release will be less than 10% of what it was in 2007 (Carvajal 2009).

Because the production cycle for salmon lasts between 1.5 and 2.5 years, the full impact of this disease on production started to appear in 2009 and will not fully be realized in the production figures before 2010. The numbers that are being reported are dramatic, as production of Atlantic salmon in Chile is expected to decrease from 211,000 tonnes in 2009 to a little more than 98,000 tonnes in 2010, down from 379,000 tonnes in 2007 and 386,000 tonnes in 2006 (Kontali 2009; FAO 2009).

While salmon disease itself is not new, the magnitude of the outbreak in Chile is staggering. Moreover, it raises a number of questions regarding disease management in

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salmon aquaculture and should provide lessons not only for salmon producers but for producers of other aquaculture species as well. As salmon is produced in relatively few countries, it is easier to obtain information about the spread of diseases and their treatment than for other species that are produced in a larger number of countries.

In this article we will provide a preliminary discussion of the disease outbreak in Chile. We expect that a number of analyses will be carried out in the future as the outbreak plays out and more information is provided.

Diseases in Salmon Aquaculture

Disease is present in all animal production, including aquaculture, and as a result disease management is an intrinsic part of animal production (Bicknell, Wilen, and Howitt 1999). There have been large outbreaks for all major aquaculture species, and with shrimp and salmon as the most valuable species, the value of the production loss has been largest for them.

There are a number of known diseases for salmon, including: vibrosis, furunculosis, Pancreas disease (PD), infectious hematopoietic necrosis (IHN), and infectious salmon anemia (ISA). Disease started to be detected in the early 1980s, and as such, has followed the industry through its development. At times, disease has threatened the industry's existence because of the economic losses following a period of significant reductions in production and destruction of infected fish. Among the most significant outbreaks are vibrosis in Norway in 1986, furunculosis in Norway in the early 1990s, and ISA in the Bay of Fundy in Canada just after the turn of the century, and the Faroe Island in 2003. So far, the ISA outbreak in the Faroe Islands is certainly the most serious in relative terms, and it is most likely also the most serious when it comes to production loss, as production was reduced from 47,000 tonnes in 2004 to 12,000 tonnes in 2006 before it started to rebound.

It is also worthwhile to note that there are no recorded major disease outbreaks of any kind in Scotland and no major outbreaks of ISA in Norway. This is the case despite several isolated ISA outbreaks in both countries.[1] However, while these outbreaks have been serious for single companies, and also regions at times, the spread of the disease has been limited. There are several ways to contain a disease. Some diseases, such as vibrosis and furunculosis are not really a threat anymore because of effective vaccines. For others, lack of or less effective vaccines make other measures, such as zoning of farms, regulations of distances between farms, and destruction of fish when a disease is detected, important tools in disease management. Regulatory tools are necessary to implement such measures, and experiences of the regulatory bodies and individual firms in combating disease lead to more efficient disease management schemes.

It is hard to obtain good data on most issues related to disease. However, antibiotic use in Norway presents an interesting illustration of changes in the measures used for combating disease. Figure 1 shows total Norwegian salmon production and use of antibiotics during the period 1980–2007. An early response, as in many other animal production operations, was to mix antibiotics into the feed. During most of the 1980s, the use of antibiotics increased even more rapidly than the production of salmon, with 48,570 kilos being used in the highest year (1987) for a production of 46,000 tonnes. The use of antibiotics had significant negative environmental externalities, particularly on the benthic fauna around the farms.

Pollution, including the use of antibiotics that negatively impacted the local environment, also influenced the productivity of salmon farms at each location, giving farmers incentives to reduce the local pollution (Asche, Guttormsen, and Tveteras 1999). Together with regulatory measures to combat disease, the negative feedback effects on productivity

[1] There lacks transparency in reporting disease in most places, particularly in the UK, so although it is clear that no major outbreaks have taken place, one cannot say much about the frequency and distribution of outbreaks.

also provided the industry with incentives to reduce the use of antibiotics. A major breakthrough came with the first vaccine, which was commercially introduced in 1991.[2] As one can see in figure 1, this rapidly reduced the use of antibiotics, and in 2007 649 kilo was used for the production of 822,000 tonnes. The increased use of antibiotics in the 1980s illustrates that it takes time to detect and address a problem. However, the solution (the vaccine in this case) can reduce the environmental impact of the industry significantly, as suggested by Tveterås (2002).

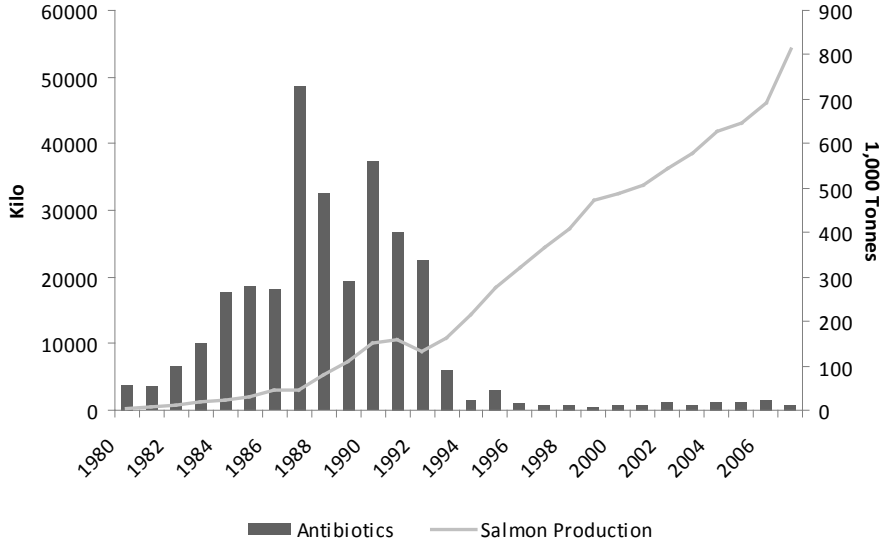

Figure 1. Norwegian Salmon Production and Antibiotics Use, 1980-2007

Source: FAO 2009; Kontali 2009; Tveterås, S. 2002; Norwegian Institute of Public Health 2009.

While the industry has certainly learned a lot about combating salmon diseases in the Northern Hemisphere, they remain part of the productive environment and are still able to bankrupt individual companies in Norway and Scotland—the two countries where salmon aquaculture first reached significant quantities. However, their effects are limited for the industry at large. In Eastern Canada and the Faroe Islands, on the other hand, ISA caused significant damage after the turn of the century. The Faroe Islands were particularly hard hit, as production was reduced to just one fifth of what it was at its peak, despite several companies from other countries with ISA experience operating there. Hence, disease seems to spread faster than experience on how to combat it.

Chilean Production and ISA

Chile is the last of the major salmon-producing nations where aquaculture commenced. Production of Atlantic salmon is shown in figure 2 from 1991, the first year when production exceeded 10,000 tonnes.[3] Until 2005, Chile was the fastest-growing salmon producer

[2] Currently, most Norwegian smolts are vaccinated. It is worthwhile to note that the vaccines are not effective against all diseases and that there is an important relationship between breeding goals with respect to disease resistance and vaccines.

[3] There is also significant production of salmon trout and coho in Chile. In 2008 the production of salmon trout was 179,000 tonnes and coho was 116,000 tonnes. However, there is no indication that the reduction in Atlantic salmon production led to an increase in the production of these species.

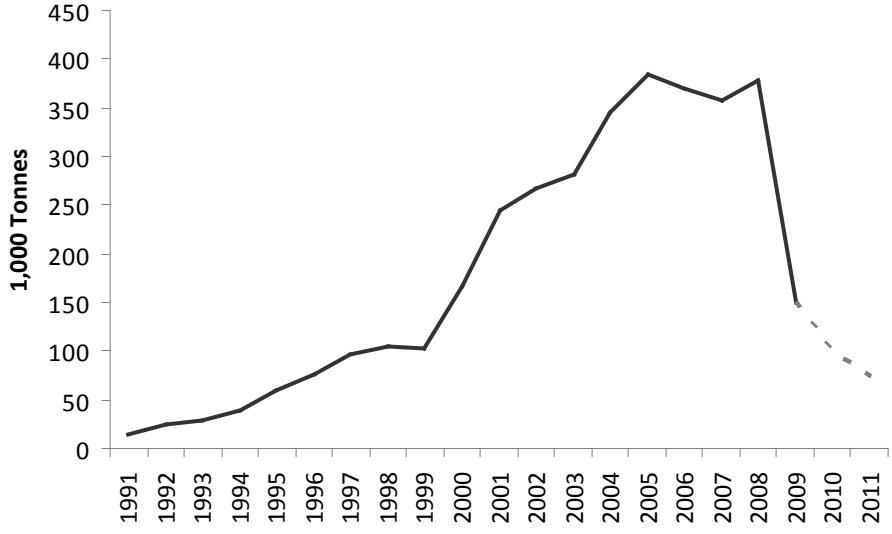

Figure 2. Chilean Production of Atlantic Salmon, 1991-2011

Sources: FAO 2009; Kontali 2009; 2009-2011 (authors' forecast).

in the world, overtaking Scotland as the second largest producer of salmon (including coho and salmon trout) in 1992 and Atlantic salmon in 2000. In 2005, total Chilean production was only a few thousand tonnes shy of Norwegian production and of Chile becoming the world's largest salmon producer.

Growth in Atlantic salmon production in Chile started to stagnate in 2005, and production peaked in 2005. This is an indication that there were problems earlier, despite the fact that the first report of the ISA outbreak was in 2007. A source indicates that strains of ISA have been present in Chile since the late 1990s (Kibenge *et al*. 2009). However, it is still very hard to obtain any information with respect to the prevalence of viruses and disease in Chile. When Marine Harvest reported the outbreak of ISA in 2007, it was, at least in public, regarded by the industry as a separate problem for the company (Carvajal 2009). Although there were more reports of disease outbreaks in 2008, they were still regarded as single occurrences, and there was little sense that this was a problem for the industry at large. Only in late 2008 did a majority of the companies start to regard ISA as a challenge that required consorted action by the industry. The government got seriously involved, but the industry discovered that the government had no tools to coordinate the effort (*The Economist* 2009).

As the disease is now playing out, it seems to be at least as serious as what happened on the Faroe Island in relative terms, and much larger in absolute terms, as the Chilean industry is much bigger. A number of companies have now emptied their pens, and it is in the production numbers for 2009 that one will start to see how hard the industry is being hit. The production volume is highly uncertain, but most commentators indicate numbers around 200,000 tonnes (Carvajal 2009; Kontali 2009; *Diario Financiero* 2009). It is also reported that the smolt release in 2009 is down to less than a tenth of what it was in 2007. This indicates that there will be very little fish to harvest in 2010 and eventually in 2011, and even with good growth rates, Chilean output is unlikely to reach much above 100,000 tonnes. This means that compared to the production level in 2007, production will be reduced cumulatively by at least 700,000 tonnes during the period 2009–11, and production value will be reduced by more than 2 billion USD.

Why Wasn't the Industry Prepared?

What any observer of this crisis will wonder is why wasn't the Chilean industry prepared at all? After all, the companies operating in Chile knew that the ISA virus was present and that it had caused serious problems in all other major salmon-producing countries. The lack of an adequate response is even more surprising, given that several of the multinational companies have considerable experience with the disease from other production areas. In addition, why was there such a lack of transparency about the problems? We know that Marine Harvest was the first company that reported the disease in 2007 and that there has been significant reluctance among other companies to report disease outbreaks. Hence, the disease was allowed to spread for at least one year after the first outbreak was reported without the introduction of countermeasures (Carvajal 2009). The production numbers for Atlantic salmon in figure 2 give the impression that the disease problems were prevalent earlier than they were reported, as it is hard to come up with other explanations why production peaked in 2005.

One likely reason why disease was not combated earlier is the economics of the operation. Salmon is an exotic species in Chile, as are the diseases. Hence, when salmon farming commenced in Chile in the late 1980s, the local fauna was disease free. Moreover, with liberal regulations the producers could focus on scale economies that are significant in the industry (Guttormsen 2002; Asche, Roll, and Tveteras 2009) and possibly also external economies of scale that have been documented in Norway (Tveteras 2002).

The Chilean industry seems, on the other hand, to have overlooked the significant production risk that has been documented for the industry (Asche and Tveteras 1999; Kumbhakar and Tveteras 2003). Disregarding the production risk posed by disease outbreaks may initially have been good for the competitiveness of the Chilean industry, as most risk-reducing measures are costly. In particular, the use of freshwater lakes rather than land-based closed smolt plants reduced investments in smolt production. Unvaccinated fish grow faster than vaccinated fish, implying lower production costs. Imports of fish roe continued in significant quantities, allowing the industry to proceed without enacting its own breeding programs.[4] Maybe this is sensible as long as disease is not present in the local fauna. However, when the Chilean industry knows the effects of disease in other countries and still does not take any measures, it seems irresponsible.

A problem is, of course, the lack of transparency and underreporting of disease. As noted above, there are strong indications that it was known that the ISA virus was present in Chile in the late 1990s. Moreover, the peak in 2005 of Atlantic salmon production suggests that the disease problems started earlier than the first ISA report made by Marine Harvest in 2007. Another indicator of disease outbreaks prior to 2007 is the use of antibiotics, which the Chilean government reported in July 2009 was 326 metric tonnes in 2008, down from 386 tonnes in 2007 (Ministerio de Economía, Fomento y Reconstrucción 2009). Chile used 350 times more antibiotics than Norway per kilo of salmon produced in 2008. In 2003 the Chilean industry used 134 tonnes, 318 times more than in Norway per kilo produced.[5] As these three years are the only ones we have information on with respect to antibiotic use in Chile, it is hard to discuss trends. However, it seems clear that the Chilean industry has followed the development that figure 1 shows for the Norwegian industry in the 1980s, but so far clearly without passing the peak. Moreover, it is hard to come up with other explanations than that they were combating disease given

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[4] This is important, since it seems that imported roe is a carrier of the ISA virus to Chile (Carvajal 2009). Of course, since salmon is an exotic species, the first roe had to be imported, but it is an interesting argument whether those imports should have been abandoned at some point and overtaken by domestic producers as a risk-reducing measure.

[5] <http://www.patagoniatimes.cl/index.php/20080708584/News/Salmon-News/NYT-SOURCE-BITES-BACK-SLAMS-CHILES-SALMON-INDUSTRY.html>.

the large quantities of antibiotics used. The recently reported figures contrast the Norwegian figures shown in figure 1, indicating very different strategies in combating disease.

One may wonder why companies that have experience with ISA and other diseases from other countries have chosen not to use this experience in Chile, and why Chilean authorities have failed to learn anything from the disease outbreaks in the other countries and only recently introduced new measures, such as increased inspections of farming facilities, new zoning regulations, etc. However, the ISA outbreaks in Canada and the Faroe Islands certainly indicate that the Chilean case is not unique. The fact that ISA has been and still is a serious disease in Norway and Scotland, but does not threaten more than at most a few companies in a limited region, shows that experience from combating other diseases also helps limit new disease.

Concluding Remarks

Disease is a part of animal production, and as such it is not surprising that it is also a part of aquaculture. As intensive aquaculture is a relatively new industry, one can learn about disease only as it occurs. When that happens, it takes time to learn how to most effectively combat each disease. The experience in Norway and Scotland indicates that developing disease management schemes is possible and that experience from combating some diseases also helps in preventing or reducing the impact of new diseases. As in agriculture, government has an important role to play in providing regulations and in implementing emergency measures that help to coordinate the industry in its preventive efforts.

In this light, the consequences of the ISA outbreaks in Canada, the Faroe Islands, and now in Chile, are discouraging. Even in an industry like salmon farming where production is limited to a few countries and with several multinational companies that have the ability to transfer knowledge between these countries, there actually seems to be very little transfer of experiences in disease management. Hence, ISA wreaked havoc first in the Bay of Fundy, then the Faroe Islands, and finally in Chile, despite the experiences of Norway and Scotland. Moreover, regardless of the importance of different government bodies, the governments in these different countries seem to have a very limited capacity to learn from other countries that have faced similar challenges.

When it is so difficult to learn from others' experiences in salmon aquaculture, a relatively transparent industry present only in relatively developed countries, disease will create an even larger challenge to aquaculture development in less developed countries. To some extent, the experience from shrimp and other species has already demonstrated these governance problems (Bondad-Reantaso *et al*. 2005). However, even if disease is present, the experience from Norway and Scotland indicates that large-scale aquaculture can be conducted in a sustainable manner (Asche 2008). The current disease problems in Chile demonstrate that good governance is essential to reach this objective.

References

Asche, F. 2008. Farming the Sea. *Marine Resource Economics* 23(4):527–47.

Asche, F., A.G. Guttormsen, and R. Tveteras. 1999. Environmental Problems, Productivity and Innovations in Norwegian Salmon Aquaculture. *Aquaculture Economics and Management* 3(1):19–29.

Asche, F., K.H. Roll, and R. Tveteras. 2009. Economic Inefficiency and Environmental Impact: An Application to Aquaculture Production. *Journal of Environmental Economics and Management* 58(1):93–105.

Asche, F., and R. Tveteras 1999. Modeling Production Risk with a Two-Step Procedure. *Journal of Agricultural and Resource Economics* 24(2):424–39.

Bicknell, K.B., J.E. Wilen, and R.E. Howittt. 1999. Public Policy and Private Incentives for Livestock Disease Control. *Australian Journal of Agricultural and Resource Economics* 21:501–21.

Bondad-Reantaso, M.G., R.P. Subasinghe, J.R. Arthur, K. Ogawa, S. Chinabut, R. Adlard, Z. Tan, and M. Shariff. 2005. Disease and Health Management in Asian Aquaculture. *Veterinary Parasitology* 132(3-4):249–72.

Carvajal, P. 2009. ISA and the Reshaping of Chile's Salmon Industry. *Intrafish Industry Report*, May. Bergen: Intrafish.

Diario Financiero 2009. Producción de Salmón del Atlántico Podría Caer más de 70% Durante 2010, March 3.

FAO. 2009. Fishery Information Data and Statistics Unit. Fishstat Plus v. 2.30. Rome: FAO.

Guttormsen, A.G. 2002. Input Factor Substitutability in Salmon Aquaculture. *Marine Resource Economics* 17(2):91–102.

Kibenge, F.S.B., M.G. Godoy, Y. Wang, M.J.T. Kibenge, V. Gherardelli, S. Mansilla, M. Lisperger, G. Jarpa, G. Larroquete, F. Avendaño, M. Lara, and A. Gallardo. 2009. Infectious Salmon Anaemia Virus (ISAV) Isolated from the ISA Disease Outbreaks in Chile Diverged from ISAV Isolates from Norway around 1996 and was Disseminated around 2005, based on Surface Glycoprotein Gene Sequences. *Virology Journal* 6(88):1–16.

Kontali. 2009. Personal communication with Ragnar Nystøl, July.

Kumbhakar, S.C., and R. Tveteras. 2003. Risk Preferences, Production Risk and Firm Heterogeneity. *Scandinavian Journal of Economics* 105(2):275–93.

Ministerio de Economía, Fomento y Reconstrucción. 2009. Letter from H.L. Montes 14 July informing on antibiotics usage in the Chilean salmon industry.

Norwegian Institute of Public Health. 2009. Forbruk av Legemidler i Norsk Fiskeoppdrett i 2001–2008 Consumption of drugs in Norwegian Fish Farms 2001–2008) <http://www.fhi.no/eway/default.aspx?pid=233&trg=Area_5774&MainArea_5661=5565:0:15,2675:1:0:0:::0:0&MainLeft_5565=5774:0:15,2675:1:0:0:::0:0&Area_5774=5544:73845::1:5776:1:::0:0>.

The Economist. 2009. Dying Assets: Chile's Stricken Salmon Farms, Jul. 30th.

Tveteras, R. 2002. Industrial Agglomeration and Production Costs in Norwegian Salmon Aquaculture. *Marine Resource Economics* 17:1–22.

Tveterås, S. 2002. Norwegian Salmon Aquaculture and Sustainability: The Relationship between Environmental Quality and Industry Growth. *Marine Resource Economics* 17(2):121–32.