Marine Resource Economics, Volume 23, pp. 395–400
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0738-1360/00 $3.00 + .00

Aquaculture—Opportunities and Challenges Special Issue Introduction

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Introduction

Aquaculture, or husbandry of different fish species, has been practiced for centuries worldwide. The ancient Egyptians and Chinese cultured different species thousands of years ago. However, aquaculture was not very important in terms of quantity produced before the 1970s. Then a significant change took place as control of the production process enabled a number of new technologies and production practices to be implemented, improving the competitiveness of aquaculture products as a source of basic food, as well as a source of revenue. The competitiveness of aquaculture has further been amplified by product development and marketing made possible by a more predictable supply. The combined effect of productivity and market growth has made aquaculture the world's fastest growing animal-based food sector during the last decades (FAO 2006).

The annual growth rate in aquaculture production has been 7.05% since 1971 (FAO 2008). During this period, aquaculture has grown from an insignificant provider of seafood to an important provider of protein for human consumption. This can be seen in figure 1, where the development in the landings of wild seafood and aquaculture production is shown. In 1970 aquaculture production was still rather miniscule, with a produced quantity of about 3.5 million tonnes. This made up 5.1% of total seafood supply. In 2006, aquaculture comprised 41.8% of total seafood supply. Fisheries production, on the other hand, has experienced no trend in growth since the late 1980s, and has fluctuated between 90 and 100 million tonnes in annual landings. Increased aquaculture production is accordingly the only reason why global seafood supply continues to grow. Moreover, increased production has been sufficient to not only maintain, but also to slightly increase, global per capita consumption of seafood.

When it comes to fish aimed directly for human consumption, aquaculture is even more important. The main reason for this is that significant quantities of wild fish are used for other purposes, such as fish meal and fish oil. In 2007, the per capita consumption of seafood from aquaculture was 8.1 kg and 8.5 kg from wild

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The papers published in this special issue were initially presented at a workshop on aquaculture economics at Refsnes Gods, Norway, August 21-22, 2007. Financial support from the Norwegian Research Council and the Norwegian Seafood Export Council is acknowledged. We would also like to thank the editor of *Marine Resource Economics*, Professor James L. Anderson, and the technical editor, Barbara Harrison, for their support.

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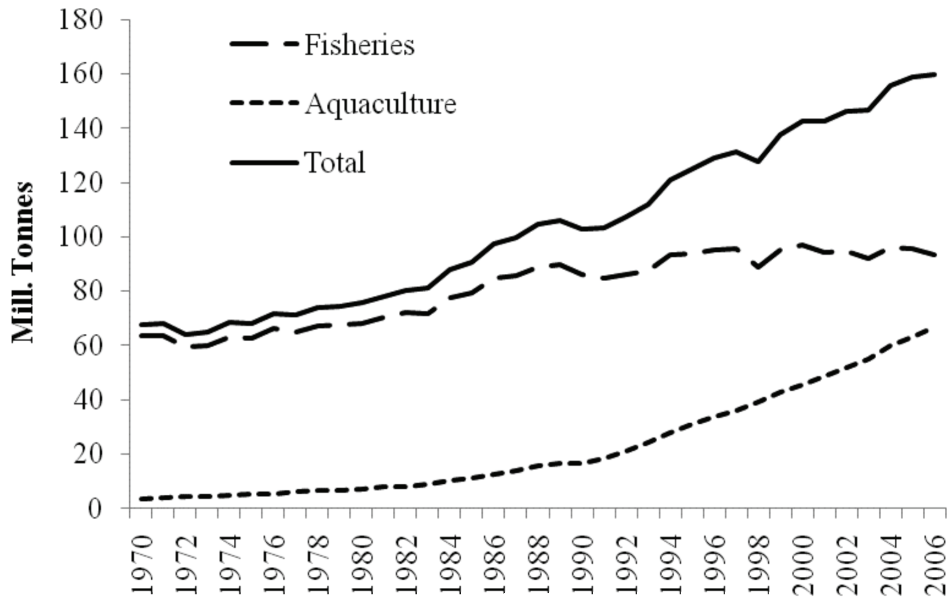

Figure 1. Global Production in Fisheries and Aquaculture 1970–2006
Source: FAO (2008).

fisheries (Lem and Einarson 2008). If the current production trends are maintained, aquaculture should reach parity with capture fisheries in the contribution towards food fish consumption in 2008. Hence, aquaculture is already as important as wild fisheries as a source of seafood for human consumption.

Given the status of global fisheries, with most large fish stocks being fully exploited or over-exploited, aquaculture production must increase in order to maintain or increase the global seafood supply per capita. Fortunately, the aquaculture sector seems well positioned to succeed in this respect.

By obtaining control over the production process and closing the production cycle for an increasing number of species, research and innovation similar to what has taken place in agriculture is rapidly improving the competitiveness of aquaculture, and the blue revolution is following the green revolution. The blue revolution has benefits largely similar to the green revolution in that humanity's capacity to produce food is increased, more people are able to provide for themselves, and fewer people are starving. By increasing food production, aquaculture also has positive environmental effects, as there is less pressure on marginal terrestrial land and it reduces incentives for deforestation. However, the blue and green revolutions face many similar obstacles in that more intensive production practices and new crops create new environmental impacts and challenges. Moreover, as societies and land use change, not everyone benefits, and there is further potential for socioeconomic challenges.

High Risk, but High Growth and Return as Well

Modern aquaculture ranks among the most risky businesses to enter as an entrepreneur, farmer, or investor. The risk begins with the production process, as farms face several substantial biophysical uncertainties related to disease, water environment, environmental, and climatic conditions (Tveteras 1999, 2000; Kumbhakar 2002). For many species a long production cycle from fingerlings to harvest contributes to the production risk. Market prices for most aquaculture species exhibit significant volatility, market access is often restricted by changing trade regulations, and new competitors continuously enter the market (Anderson 2003). There are many causes of market risk. Obvious sources are shifts in total supply from farmers and consumer demand that is not fully anticipated when production decisions are made. When aquaculture products are marketed in the international arena, which is the case for most aquaculture species, producers face risks related to exchange rate, antidumping, sanitary and veterinary regulatory changes, and other trade barriers. Finally, aquaculture products are increasingly marketed through large retail chains, where there are risks related to retailers' bargaining power and extensive requirements to suppliers in terms of deliveries (volume, timing, *etc.*), documentation, certification, *etc.*

Despite high economic risks, the global aquaculture industry continues to attract new production capacity, new entrepreneurs, and new investors. This is a clear sign of the profitability of the industry, as high returns are the market's signal to attract more investors and increase production.[1] There are two main explanations for this development. The first is a strong underlying growth in the global demand for seafood. This primarily benefits aquaculture as fisheries production cannot grow much above current levels. As an increasing number of the world's people, particularly in Asia, climb from poverty to the middle class, further growth driven by the demand for variety in protein intake and health concerns is expected. The second is rapid development in the technologies on which aquaculture depends, leading to an almost continuous increase in productivity and quality over time. There is still much room for improvement; *e.g.,* in genetic material, feed formulations, disease control, logistics, distribution, and marketing. With large differences in technological sophistication between different species and regions, one can expect productivity development in aquaculture to continue to improve the competitiveness of aquaculture species, and with increased demand the production will be profitable. However, as new technologies are adopted, the cyclical and risky nature of the industry will also continue. The articles in this special issue directly or indirectly address the whole spectrum of risks from farm to table described above.

Guttormsen develops an extended version of the well-known Faustmann model for solving the optimal rotation problem in fish farming. Two particularly important aspects of the problem are emphasized; the possibilities for cycles in relative price relationships and the problem with limitations in release time for certain species. An illustration of the model based on assumptions from salmon farming shows that the inclusion of these two features has major influences on rotation time, and thus harvesting weight.

Gordon, Bjørndal, Dey, and Talukder present an intra-farm study of production factors and productivity for shrimp farms in Bangladesh. The analysis is based on a panel of farms for the period 1998 to 2002. The data allow for a profit decomposition based on the Törnqvist index, where differences in relative profits can be

[1] The link between productivity growth, production cost, and increased production is discussed in Asche (1997); Guttormsen (2002); and Asche, Roll, and Tveterås (2008).

explained by differences in productivity, prices, and pond size. The indices indicate that pond size is the most significant factor in determining profitability and that the largest farms are the most profitable. However, productivity measured as profit per hectare is only weakly positively correlated with pond size. In fact, the smallest ponds rely more on productivity in generating profit relative to the most profitable farm. These results indicate that small farms are disadvantaged not because they lack skilled management, but because the farms are too small. The challenge for Bangladeshi policy makers is to devise methods and procedures to allow small farmers to expand pond size.

Andersen, Roll, and Tveterås analyze the price responsiveness of salmon supply in the short and long run. Productivity growth and competitiveness indicate that salmon supply is price responsive. However, in the short run, supply is likely to be constrained by the biological production process, regulations, and capacity constraints. The authors estimate a restricted profit function for Norwegian salmon producers using data spanning 1985 to 2004. They find that there is close to zero own-price supply responsiveness in the short run. In the long run, this changes substantially as supply increases above unity. This result can contribute to explaining the observed cyclical profitability in the salmon farming industry.

Xie, Kinnucan, and Myrland analyze the effects of currency exchange rates on salmon export prices. The CBS inverse demand system of Keller and van Driel is extended to include exchange rates. When applying the extended model to farmed salmon trade data, the results suggest export prices are at least as sensitive to changes in exchange rates as to changes in trade volume. Exchange rate pass-through (absorption into export prices) is complete for the Chilean peso and the British pound, but incomplete for the Norwegian kroner and the US dollar. This suggests producers in Chile and the United Kingdom are more affected by short-term movements in relative currency values than producers in Norway and the rest of the world. Model simulations suggest currency realignments, especially depreciation of the Chilean peso, contributed to the 2003–04 collapse in world salmon prices.

Keithly and Poudel analyze the factors that led US shrimp harvesters and processors to file a petition against foreign shrimp producers, the investigation process, and the outcome associated with the imposition of antidumping duties. After an exhaustive investigation, an affirmative finding of dumping and injury was found, and duties were imposed on subject merchandise from China, Vietnam, India, Thailand, Ecuador, and Brazil. Overall, the study concludes that while the duties resulted in a limited amount of trade deflection, particularly among those countries assessed with higher duties, much of the protective effect that might have been forthcoming from restricting imports from the six named countries was eroded by trade diversion to countries not included in the petition.

Fofana and Jaffry analyze retail firms' ability to exercise market power in the purchase of supplies (oligopsony power) in light of a significant increase of concentration in the UK salmon retail subsector. To assess the extent to which retail firms have exercised oligopsony power, they develop a dynamic error correction translog profit function to model the behaviour of retailers in the input market for smoked, fillet, and whole salmon. The estimated indices of market power in the models were low and statistically significant but sufficiently close to the perfect competition benchmark, indicating that retailers as a whole behaved competitively during much of the study period.

Oglend and Sikveland analyze the volatility structure of salmon prices. An understanding of the structure of volatility is of great interest, since this is a major contributor to economic risk in the salmon industry. The volatility process in salmon prices was analyzed based on weekly price data from 1995 to 2007. The Generalized

Autoregressive Conditional Heteroskedasticity (GARCH) model was used to test for volatility clustering and persistence of price volatility. They find evidence for and discuss the degree of persistence and reversion in salmon price volatility. Further, they find that volatility is greater in periods of high prices. For the industry this means that larger expected profits often come with the tradeoff of increased price risk.

Asche discusses the main drivers in the production process that have resulted in tremendous growth in aquaculture production and argues that this development has a number of similarities to the development of modern agriculture. The main point is that control of the production process allows innovation and technological progress that improve the competitiveness of aquaculture producers. Control of the production process also allows for innovation in the supply chain, leading to more efficient logistics and improved conditions for product development and marketing. Moreover, while large-scale aquaculture has the potential of serious environmental damage, management of the production process provides farmers control over environmental impact, which may enable sustainable, environmentally responsible aquaculture production.

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