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Introduction

Global production of seafood – wild and farmed – has more than doubled over the past three decades, from 65 million tonnes in 1970 to 142 million tonnes in 2008 (Figure 1.1). Landings of wild fish increased from 63 million tonnes in 1970 to almost 90 million tonnes by the end of the 1980s, and have remained near that level ever since, although there are fluctuations from year to year. According to the Food and Agriculture Organisation (FAO 2009), there is little reason to expect an increase in the production from wild stocks in the foreseeable future.

During the same period, a revolution in aquaculture technology occurred, leading to a very substantial increase in production. As can be seen in Figure 1.1, aquaculture production (excluding aquatic plants) was relatively insignificant in 1970, producing about 2.5 million tonnes, or approximately 4% of total seafood production. By 2008 this had increased to 52 million tonnes, or about 37% of the total seafood supply. Consequently, even with stagnant landings of wild fish, the supply of seafood has been steadily increasing. Moreover, the supply of seafood has been growing not only in absolute quantity but also more rapidly than global population. Hence, the per-capita supply of seafood has also increased over the three last decades. The importance of aquaculture not only as a source for seafood but also for food in general is also set to continue to increase (Smith *et al.* 2010).

Salmon and shrimp are the leading species in modern industrialised aquaculture. Farmed salmonids (Atlantic and coho salmon and salmon trout) account for only about 4% of total aquaculture production but almost 13% of production value. Shrimp has a share of about 6% of production volume and accounts for more than 16% of production value. Between them, salmon and shrimp, the two most intensively farmed species, represent almost 30% of global aquaculture production value. Their production growth rates have been approximately the same as for aquaculture in total over the last 30 years. This is significant, given that they are relatively high value products. The higher value is at least partly due to the fact that these two species are among the most traded ones. In particular, most of the

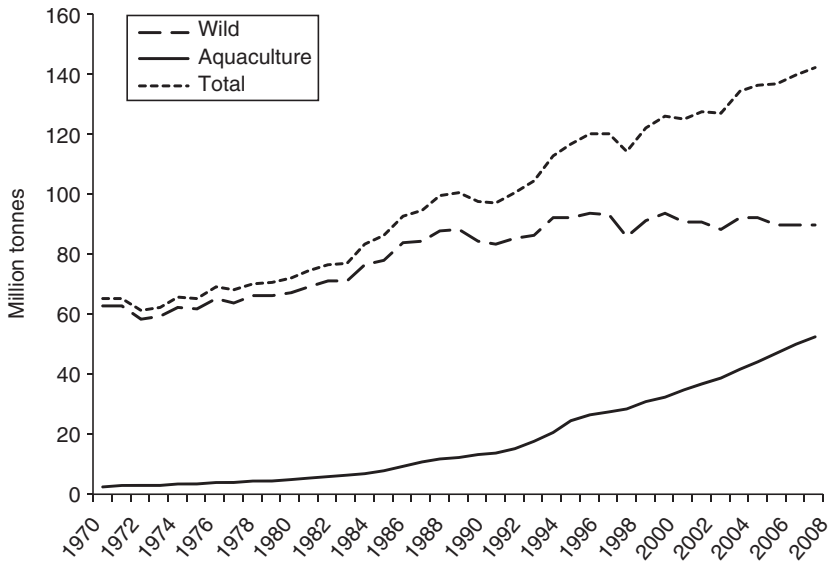


Figure 1.1 Global production of fish and seafood, 1970–2008. (Source: FAO)

production is consumed in the three largest markets for seafood as measured by value, the European Union (EU), Japan and the USA. Within these regions, market size was increased by expanding the geographical area where the products were consumed, as well as by reaching new consumers by reducing prices, developing new product forms and using new sales outlets.

With respect to quantity consumed, salmon is now among the top five species in most major seafood markets. Farmed salmon production – Atlantic salmon, coho and salmon trout – has increased from a few thousand tonnes in 1980 to about 1.9 million tonnes in 2008 (Figure 1.2). Salmon, together with shrimp, has in many ways led the aquaculture ‘revolution’ since the 1970s. While there are many differences in the development of these species, there are also a number of important similarities that other new aquaculture species are likely to emulate. Key to the aquaculture revolution is control of the production process. It is this control that makes technological innovations possible, which in turn allows lower production costs and a more affordable product to the consumers. This can be contrasted with wild harvest, where the fishers have to search for fish and have little influence over the composition of the catch. Furthermore, one has limited control over the timing of the harvest so that it is difficult to design efficient logistics systems and to address market needs.

Salmon aquaculture is of interest in itself, as well as an example with respect to opportunities and challenges that most other successful farmed species are likely to meet. It is a global industry with production on all continents except Africa, although there are two leading producing nations,

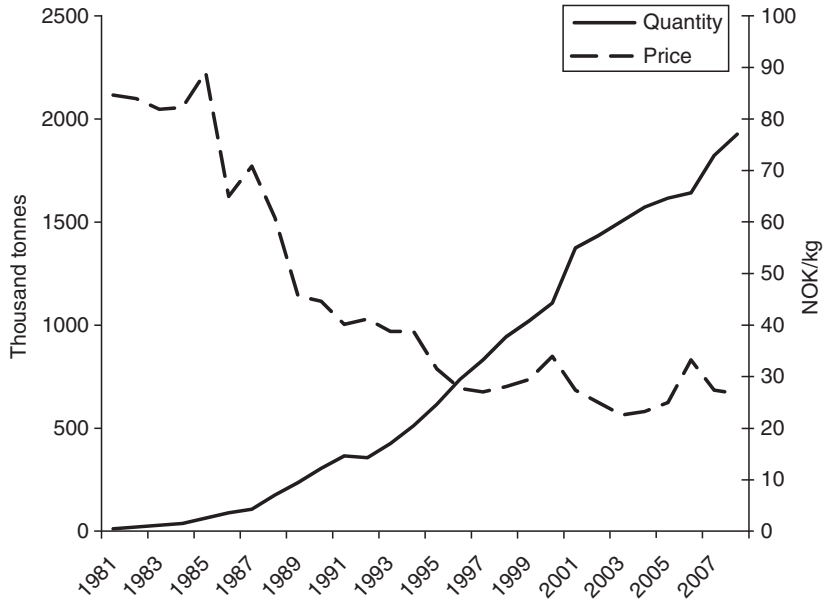


Figure 1.2 Global production of farmed salmon and real price, 1981–2008. NOK, Norwegian kroner. (Sources: FAO, Kontali, Norwegian Seafood Exports Council)

Chile and Norway, in two different continents and with different degrees of economic development. Salmon aquaculture is a rapidly expanding profitable industry. Moreover, it is a knowledge-based industry, and is in the forefront when it comes to technology, innovation and productivity development in aquaculture. Salmon aquaculture shows how technological innovation can create large-scale food production, and holds several important lessons with regard to how to develop aquaculture as a food production technology that increases the world's food producing ability, and as an industry capable of providing economic development in coastal communities. Finally, salmon aquaculture has experienced a number of environmental challenges that have forced farmers to change their practices to make the industry sustainable. Similar challenges are likely to face most other intensive aquaculture operations.

Control of the production process and the predictability of supply in aquaculture have profoundly changed the ways seafood can be marketed, and further contributed to the industry's success. Although control of the production process is essential for an aquaculture industry to be established, the market is equally important for a successful industry. Even with small volumes in the early 1980s, a fish buyer could achieve higher revenues or cost savings using salmon rather than other seafood because the supply was predictable. The supply could be adjusted so that more salmon were available in periods with peak demand like seasonal holidays, and

also as a fresh product. As volumes grow, these advantages continue to be important. Processors like smoking houses can avoid a frozen inventory and utilise a just-in-time logistic system. Retailers can plan advertising campaigns months in advance, as with most other products (except wild seafood), and know that the quantity they require will be available when the campaign is run. The control of supply has also created the foundations for product development, as lower prices have made a new array of products affordable for consumers and profitable for processors.

The control of supply allowed sellers to target the most valuable markets, market segments and product forms. In particular, most farmed salmon is sold fresh in contrast to most wild-caught salmon that is sold frozen, tinned or in other highly conserved product forms. Fresh salmon is sufficiently valuable to justify airfreight from Europe and South America to Japan and the USA. To airfreight large volumes of seafood is but one of many innovations in logistics and distribution that control of the production process has permitted. The total result is substantial for competitiveness, as a Norwegian salmon farmer gets about 50% of the retail value of a whole salmon, as compared with 10–25% for a cod fisherman.

In the 25-year period during which salmon farming has been commercially significant, the industry, as well as the markets, has changed substantially. In particular, as shown in Figure 1.2, the strong increase in production has been associated with a substantial reduction in prices. The real price in 2008 was less than one-third of the price in the early 1980s.¹ Moreover, the price is likely to continue to decline in the longer term due to further productivity growth. The price reduction is to a large extent necessary if the industry is to continue expanding because the reduced price is the main factor in attracting new consumers of salmon.

Although we will elaborate on these issues in later chapters, they allow us to introduce the most important factors in the development of salmon aquaculture here. Control of the production process makes possible technological innovations that reduce cost of production. The reduced cost of production makes the industry profitable, and since good profits is the market's signal that it wants more of the product, this leads to increased production. However, to sell the increased production, one has to reduce prices to attract more consumers to buy salmon rather than other products. This reduces profits, and creates cycles in profitability. Over time, the equilibrium is where the produced quantity results in a price that gives the investor in the salmon industry the same risk-adjusted return on capital as in any other industry. However, with rapid innovations and market growth, this is a moving target. The cycles in profitability also create trade tensions, as most of the salmon is produced in a different country from where it is consumed.

¹ A value or a price expressed in real terms is adjusted for inflation to make numbers comparable over time.

In this book we will provide an analysis of what we regard as the main factors that have created the salmon aquaculture industry, as well as the main opportunities and challenges facing it. As such, the primary discussion will be both backward looking to learn from the development so far, and forward looking with respect to future development.

This book comprises two main parts. In the first part (Chapters 2–8) we focus on the development of salmon aquaculture and its lessons for aquaculture in general. In this part we discuss the biological and technical foundations for salmon aquaculture (Chapter 2), and how production has developed in the main producing countries as well as the regulations (Chapter 3). This is the foundation for discussing how productivity growth has occurred and been the main engine in the growth of salmon aquaculture (Chapter 4). A major feature in this process is how salmon aquaculture interacts with the environment, and how control of the production process allows the industry to be sustainable when externalities are taken into account (Chapter 5).

While productivity growth has been essential for the growth in salmon aquaculture, expanding the market geographically and increasing the number of product forms have also been important for the success of the industry, even though market access at times has been problematical due to trade restrictions (Chapters 6 and 7). We show that many of the characteristics of the successful development of salmon are similar to those for other successful species (Chapter 8). Hence, the insights that can be derived from salmon will to a large extent also be valid for ‘new’ species that are currently being developed.

In the second part (Chapters 9–11) we focus on the operation of a single firm. We start out by discussing the economic theory for optimal harvesting of the fish (Chapter 9). This model is then applied using data for western Norway to illustrate the economic decisions involved in growing and harvesting a single batch of fish (Chapter 10). This information is used as a foundation for the production plan and investment decisions for a modern farm, releasing 1 million smolts each year (Chapter 11). The investment analysis also provides the information necessary to estimate the value of an aquaculture business.

