Trade Intervention:

Not a Silver Bullet to Address Environmental Externalities in Global Aquaculture

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Abstract

Aquaculture has been the world's fastest growing food production technology in recent decades, and continued growth in aquaculture production is predicted. While creating economic opportunity, aquaculture is also a new way of using eco-systems, and there is substantial evidence that aquaculture creates negative environmental externalities. Although the most effective way to address these externalities may be improved governance, this approach is often difficult because most aquaculture production takes place in developing countries with limited management capacity. The fact that a large part of aquaculture production is traded motivates substantial interest in the use of trade measures to reduce environmental impacts. However, the wide variety of species, production practices, and governance systems present in aquaculture makes it unlikely that general trade measures will achieve environmental objectives. Rather, there is a real risk that trade measures will reduce economic opportunity, raise new equity concerns, and impinge on public health with little or no environmental impact.

Keywords: Seafood, Aquaculture, Trade, Environment, Public health

1. Introduction

During the last 30 years, the world´s seafood markets have changed profoundly [1]. Improved logistics, freezing and preserving technologies, and distribution as well as lower transportation costs have created global markets for a number of species, whereas previously regional or local markets dominated the seafood trade [2]. As a result, seafood is among the most traded groups of food products [3, 4]. In 2010, 39% of the seafood production was traded and an estimated 77% of production was exposed to trade competition [5]. In addition, aquaculture has substantially changed how a large share of global seafood is being produced.

In 1970, most seafood was harvested from wild stocks in capture fisheries, and aquaculture made up just 3% of total production. By 2014, aquaculture appeared to surpass capture fisheries as the larger source of seafood for human consumption, although overall wild harvests remain larger due to non-food uses such as reduction for fishmeal [6]. The rise of aquaculture is attributed to a massive increase in productivity—knowledge and techniques from agriculture were employed to gain control of the production process [7] [8]—paired with substantial growth in global seafood demand [9]. Nations and fish farmers have exploited this opportunity to meet protein needs and serve an ever growing global seafood market. Global aquaculture production increased from about 4 million metric tons in 1970 to 66.6 million metric tons in 2012. Forecasts of future aquaculture indicate a substantial increase in production in the coming decades [10]. However, aquaculture is also a new way of interacting with the environment, and with a potential to cause substantial environmental damage and social conflicts as it displaces other activities directly or indirectly due to the environmental damage [11, 12].

Given projections for substantial growth in the aquaculture sector and the significant international trade presence, the purpose of this paper is to examine the future opportunities and challenges for aquaculture production and trade with implications for trade policy. Since seafood is considered an industrial product, not included as part of agricultural production with other foods, trade policy discussions regarding seafood have differed dramatically over the years from trade policy in other food products [13]. However, like the agricultural sector, trade barriers have existed particularly in the areas of non-tariff barriers and technical barriers to trade, in part due to perceived unfair subsidization, food safety, and environmental concerns associated with aquaculture production. In this paper it is argued that aquaculture involves two distinct types of environmental externalities that differ from food safety externalities associated with international trade in seafood: local externalities such as impacts on water quality near production facilities, and global externalities such as impacts on marine biodiversity. Failure to distinguish these types of externalities could compromise both effectiveness and fairness in trade policy. It is also argued that trade policies must avoid unrealistic conceptualization of the seafood trade as a vector of bilateral relationships and instead acknowledge the nuanced multilateral nature of seafood production, processing, and trade.

The remainder of the paper first provides background on the growth in aquaculture globally and its trade. Next the paper reviews the opportunities presented by aquaculture followed by the challenges (including food safety and environmental challenges), placing both in the framework of international trade and trade policy. The paper concludes with a review of possible trade policy changes that would address both opportunities and challenges faced by the aquaculture industry and communities dependent upon aquaculture.

2. Opportunities in production, innovation, and trade

Figure 1 shows the substantial increase in aquaculture production over the last 30 years. The World Bank forecasts aquaculture production of 93.6 million metric tons in 2030 (a 50% increase over 2011) with estimates ranging from 90.7 million to 116.2 million metric tons [10]. Forecasts are of an average annual growth rate of roughly 2.5%, lower than in previous decades, but likely to maintain aquaculture´s position as the fastest growing food production technology globally. The variability in projections from 90.7 million to 116.2 million metric tons reflects significant uncertainty stemming from a variety of factors, including projected growth in demand due to rising incomes in developing countries [9]. The World Bank's preferred estimate of 93.6 million metric tons suggests a much larger upside than downside potential.

Figure 1 here

Source: [6]

Increased aquaculture production is in itself an indication that, in aggregate, production is profitable for fish farming companies, as profitability is the market's signal that a producer is competitive. Thus, aquaculture is an economic opportunity that provides income and improves lives for a number of people directly as producers or indirectly at other stages in the supply chain [3].[1] Aquaculture production is also vastly heterogeneous from subsistence farmers to multinational companies [15, 16], and the social, economic and environmental impact varies between production methods and with scale.[2]

[1] There are few studies documenting employment specifically in aquaculture. However, crises like the Chilean disease crises for salmon in 2007-2012 show that a number of people have gotten jobs in the industry as many loose them during crises [14].

[2] There is also very limited data available on foreign direct investment (FDI) in aquaculture. However, it is important in some industries like Chilean salmon aquaculture [17].

The farmed seafood industry has become increasingly export oriented, suggesting that aquaculture as a whole has continued to innovate. In other food-related value chains, an export orientation and innovation go hand-in-hand [18, 19]. For aquaculture, the combination of (i) the significant investments needed to start up production and (ii) limited domestic markets for products (due for example to purchasing power constraints in developing countries, but also potentially due to the size of domestic population and other factors) provide incentives for the industry to adopt a global and innovative outlook on marketing of seafood products. China undertook a massive expansion of aquaculture beginning in the 1970s that was driven by farmed carp for domestic consumption. But in the modern seafood landscape, China is also a large exporter of farmed fish destined for industrialized countries. In 2012, the United States alone imported 612 million USD worth of frozen farmed tilapia fillets from China. Although the Chinese population is large enough to consume massive aquaculture production, per capita incomes have not been high enough to prevent the production of newer, export-oriented of high value-products. As China becomes wealthier, this trend could change. Expansion of salmon farming in Norway was also export-oriented but for different reasons; per capita incomes in Norway could afford high-value products, but the domestic Norwegian population was simply too small to support a large salmon industry focused on domestic consumption.

Innovations driving globalization in general have specifically contributed to the international orientation of the seafood industry [2]. Transportation and logistics have improved significantly. Substantial reductions in transportation costs by surface and air has promoted the international trade of fresh seafood and new products. Improved logistics have also created economies of scale and scope on all levels of the supply chain, particularly in the retail sector where supermarkets have replaced fishmongers and markets in a number of places. Progress in storage and preservation have allowed a wider range of seafood products to be traded. Freezing technology has improved to such an extent in recent years that many product forms can be frozen twice, allowing products to be processed in locations with comparative advantage in processing fish rather than in locations close to where the fish is caught. Figure 2 illustrates the complex web of seafood production, trade, and processing in which there are many possible product paths, and each can be driven by comparative advantage in production, processing, and transportation as well as demand conditions in different countries. Lastly, the improved control in the production process in aquaculture has enabled producers to serve modern consumer tastes and to innovate further in the supply chains. Taken together, these innovations dramatically reduce costs of trading seafood internationally and increase the volume seafood that can fetch high prices in international markets.

Figure 2 here

Increased production and innovations tend to reinforce each other, even though the strength of each differs by market and species. An increasing number of markets have gone from regional to global and as more species from widely different places have become substitutes [20]. The share of the imports by developed countries – the European Union, Japan, and the US in particular – remains high. However, import demand from China and other developing countries is growing as income growth contributes to increased demand [9]. Asche et al. [1] shows there is a declining import share for developed countries despite growth in total values of seafood exports from developing to developed countries. In particular, the total real value of seafood exported has grown substantially over the past four decades from 23.7 billion USD in 1976 to 82.7 billion USD in 2009 [1]. At the same time, developing countries' share of seafood exports rose steadily from 36.5% in 1976 to 49.8% in

1994, after which it has remained stable at around 50%. Exports from developing countries have thus grown faster than the total increase in exports until the mid-1990s, and they have had a similar growth rate as those of developed countries after the mid-1990s.

Beyond rising incomes, growing evidence on the health benefits of seafood consumption suggests another channel for growth in seafood demand. Sudden cardiac arrest kills 330,000 people each year in the U.S. [21]. It has been estimated that if Americans increase their consumption of fish, which contain long-chain omega-3 fatty acids, the incidence of deaths from sudden cardiac arrest could decrease by 36% [22, 23]. The USDA recently changed its dietary recommendations, stating that people should eat eight ounces of seafood per week, especially marine oily-fish to provide an average daily consumption of 250 mg of EPA/DHA (Omega-3) per day [24]. However, of the top 10 species consumed in the U.S., only salmon provides the suggested amount of desired fats per 8 ounce serving [25, 26]. To address the effects of such recommendations, a recent study by the National Research Council proposes a framework to evaluate impacts on a larger food system [26]. In an illustrative case study the analysis shows that for people to meet the recommended seafood intake, a significant increase in seafood production, particularly those high in omega-3 and low in mercury, must occur. Given the data presented above on the relative growth of seafood from capture versus aquaculture and seafood tastes of U.S. consumers, this growth likely will need to be met by aquaculture.

3. Challenges for Aquaculture

Food safety and environmental issues are fundamentally different from each other in aquaculture despite the fact that they are often lumped together in discussions of trade. For food safety, when the producer or processor causes foodborne illness or seafood contains a contaminant, the consumer is the one who is harmed. For environmental issues, seafood consumers in some cases are not physically harmed and in other cases are only harmed indirectly in the sense that there is degradation of the global environment. Specifically, one can distinguish between two types of environmental externalities in aquaculture: local externalities and global externalities, recognizing that some issues do not fit perfectly into a single category. It is also possible to distinguish between externalities that harm the producer and ones that do not. This distinction is critical because it suggests cases in which producers have market incentives to address at least some environmental problems in the absence of regulation or trade policy.

3.1 Food safety and health issues

Aquaculture has received substantial attention for containing different additives, contaminants, and toxins. One such example is a study published by Hites et al. [27], which initiated a controversy over the level of contaminants such as polychlorinated biphenyls (PCBs) found in farmed salmon relative to wild salmon. This study showed that a sample of farmed salmon contained significantly higher levels of PCBs than wild salmon, and that European-raised salmon were found to have significantly greater contaminant levels than those raised in North America, which were in turn higher than those raised in South America. Hites et al. [27] concluded that consumption of farmed Atlantic salmon may pose significant health risks from cancer and recommended that consumers limit their monthly consumption of farmed salmon to no more than 8 ounces. The media coverage of the study led to a substantial reduction of US imports of farmed salmon [28]. Comparing health benefits to risks of farmed salmon consumption suggests that the Hites et al. [27] recommendations might have harmed consumer health. For example, [22, 29, 30] all show that a reduction in fish consumption in the population would have adverse effects on human health. Willet [31] indicates that [27], and consequent media coverage, failed to consider that the lifetime benefits from farmed salmon consumption are likely to be at least 100-fold greater than the estimates of harm. In that sense, the risks identified by [27] were misleading and not beneficial to human health. Hence, food safety issues related to aquaculture production must be weighed against the health risks and benefits of decreased (or failure to increase) seafood consumption.

More generally, health risks from seafood consumption, particularly for aquacultured seafood are varied. Some health issues stem from local water quality problems where fish and shellfish are grown, such as toxic algal blooms and their effect upon shellfish or *Vibrio Vulnificus* and its effects on finfish. These concerns have more to do with the type of seafood being produced or where it is produced than whether the food is farmed or wild caught. Other issues pertain to antibiotic or other theraputant residues, and potential use of unapproved theraputants. Many other seafood-borne illnesses result from processing, handling, inadequate refrigeration, and spoilage.

While there is no doubt that aquaculture products may lead to issues for food safety, this is something aquaculture products have in common with most other foods. Codex Alimentarius sets globally agreed to threshold values to limit contamination, while developed countries have generally established more strict requirements [13]. Different countries allow for different antibiotics, and a common issue is lack of communication between importers and exporters when approved antibiotics change. Moreover, the greater degree of control in aquaculture compared to capture fisheries [7], while not a guarantee of food safety, creates an opportunity for better food safety practices. In summary, there is neither empirical evidence nor a priori theoretical arguments that aquaculture products in general pose disproportionate human health risks that are economically meaningful relative to capture seafood.

3.2 Environmental issues

Although increased income opportunities derived from aquaculture production have improved the quality of life for many across the globe [3], negative externalities created by aquaculture also impinge on that quality of life. Aquaculture's interactions with the environment can potentially cause substantial environmental damage and produce social conflicts from displacement of other activities directly or indirectly stemming from environmental damage. In sharp contrast to food safety issues, environmental externalities do not directly harm seafood consumers. Most externalities create harms within the local community where the seafood is produced. This distinction immediately raises questions of sovereignty and paternalism when environmental concerns about aquaculture are mentioned in the context of international trade. Does an importer have a right to attempt to impose its domestic environmental standards on an exporting country through trade restrictions? This issue will be further discussed below.

Environmental externalities will, to a large extent be a function of the management system they operate under, and partly the production technology used [3]. A number of studies, such as [11], investigate potential harmful environmental effects. These include: 1) land or water columns converted to aquaculture use, with possible destruction of healthy ecosystems; 2) local environmental damage due to pollution and increased nutrient loading; 3) damage surrounding ecosystems due diseases and escapes; 4) use of inputs from wild fisheries, such as broodstock or feedstock.

As the two most successful aquaculture species in terms of growth in production, salmon and shrimp are also the species that have received most attention with respect to environmental impact [11]. But the issues are pertinent to all aquaculture species with partial exceptions for shellfish. In salmon farming the primary issues have been pollution from organic waste and the interaction between wild and farmed salmon. Pollution from waste is a local externality. The pollution may not directly harm the producer, but producers have incentives to reduce local pollution to the extent that these strategies can be cost reducing. For instance, innovation in feed has lowered costs and reduced the amount of feed waste available to contribute to organic pollution [32, 33]. Another externality cited is that farmed salmon may transmit diseases and parasites to wild salmon. The extent to which these externalities are local is less clear; local wild stocks may be harmed, but there are also concerns about global biodiversity if wild stocks are compromised entirely. Increased number of the sea lice parasite on wild salmon has been associated with escaped farmed salmon. Farmed salmon may also attempt to spawn in rivers and thus may impact the wild salmon genetic pool. Again, producers have economic incentives to mitigate externalities from disease and escapes but not necessarily strong enough incentives to address the problem in a way that is socially optimal. Links between aquaculture feed and overfishing of wild forage fish present another possible global externality, but these links have never been established empirically [12, 34, 35]. Shrimp farming has received even more negative publicity than salmon farming in relation to detrimental environmental effects, such as destruction of mangroves, salination of agricultural areas, eutrophication, and disruptive socio-economic impacts. Most of these issues are local externalities as well. However, the extent to which mangroves contribute to carbon sequestration and provision of other ecosystem services raises the possibility that local impacts in shrimp farming are global externalities.

The environmental issues in intensive salmon and shrimp farming must be seen in relation to the introduction of a new technology that uses the environment as an input. In that sense, the recent environmental record of salmon aquaculture is more relevant for policy than experience in the first few decades of the new technology. In general, the larger the production at any site and the more intensive the process, the larger is the potential for environmental damage. However, the greater degree of control with the production process in intensive aquaculture relative to capture fisheries also makes it easier to address these issues. With all new technologies there will be unexpected side effects, and there will be a time lag from when an issue arises until it can be addressed. First, the impact and the causes must be identified. Second, the solution to the problems will require modifications of existing technology or may necessitate entirely new technology. In both cases, pollution reduction implies some form of induced innovation. In this respect, Tveteras [33] argues that industry growth has a positive effect on pollution (i.e. reducing it), in line with the Environmental Kuznets Curve (EKC). The EKC hypothesis refers to an empirical observation that pollution tends to increase with economic growth up to a certain point, after which growth will reduce pollution. This gives the pollution profile over time the shape of an inverted U. Use of antibiotics in Norwegian aquaculture is a good example, as can be seen in Figure 3. Producers' incentives drive to reduce costs also creates opportunities to address local (and global) externalities in aquaculture, but these innovations have taken time to unfold.

Figure 3 here

Source: [36]

There are two main reasons for the industry to address environmental effects: (1) to increase productivity and therefore profits; and (2) to avoid potential government regulations. Detrimental environmental effects of aquaculture not accounted for in market prices are negative externalities. Internalization of the externalities can explain why some of the major environmental issues have been resolved in aquaculture. The arguments go as follows: Production cost and productivity in aquaculture depend on the environment where farmed fish is raised. Fish farms with environmental practices that harm the local environment will experience negative feedback effects from poorer growing conditions that in turn reduces on-farm productivity. The result is reduced biomass growth due to poor fish health and, in the worst case, disease outbreaks that wipe out entire on-farm fish stocks. Hence, a farmer is concerned with cultivating management practices that avoid such negative repercussions on productivity.

If there is no negative feedback on expected profitability, however, it is unlikely that the industry will internalize detrimental environmental effects. In this case the government must regulate the industry to force the externalities to be internalized in production costs. The rapid growth of global aquaculture has represented an environmental challenge for authorities. First, knowledge about the environmental effects of aquaculture has been limited, or at worst lacking. This has called for extensive research to identify causes and effects. Second, in many places local governments do not have the resources to implement and enforce regulations.[3] Intensive and particularly large scale intensive aquaculture has a larger potential to give detrimental environmental effects than other technologies. The

[3] This includes the interaction between shrimp farms and mangroves. Mangroves do not provide land particularly suitable for shrimp farming. Rather, it is often the only unused land in an area and as such, the cheapest available as it is most often without formal owners.

higher degree of control with the production process does, on the other hand, also give these farmers a better opportunity to also control the negative effects of their production.[4] The core issue for aquaculture and sustainability is whether farmers choose to use sustainable practices. This will primarily be an issue of local regulations and governance, but may also be influenced by consumer initiatives and certifications resulting in ecolabels. Trade measures may also be used to influence production practices. An immediate challenge with an approach based on trade policy is that different countries have different perspectives on what are good practices, and the line between influencing management in a positive way and using such arguments to enable protectionism is a fine line. In addition, although there is not hard evidence, there is an increasing number of anecdotes suggesting that the world market for many species is already divided in two: One set of "good practice" producers with different forms of certifications such as ISO to ensure quality and possibly also environmental standards to ensure market access to those wealthy countries who care, and a set of "other producers" with lower costs that do not try to meet standards that often are regarded as excessive. As seafood trade between developing countries is increasing [1], the latter group of producers increases in importance.

With the high share of seafood being traded, trade measures may appear to be an efficient approach to address environmental concerns. However, it is important that measures are targeted at the concerns and the particular producers using back practices. Otherwise, such trade measures can prevent the economic opportunity that aquaculture is providing for a number of developing countries.

[4] The most intensive operations, closed cycle systems where all emissions are cleaned may be the most environmentally friendly systems of all. Proponents of such systems claim that clean water is the only emission.

4. The trade system

As the global trade expands, in part due to the rapid increase in aquaculture production, trade policies are becoming increasingly important. Aquaculture has been important for the increased trade for specific species, for example, salmon, shrimp, tilapia, and catfish. Not surprisingly, a number of trade conflicts and concerns have emerged that involve these species or close market substitutes.

4.1 Tariffs

Seafood is classified as an industrial product and not an agricultural product in trade. As a consequence, tariffs are in general much lower than for many other food products. There is tariff escalation to promote processing of seafood in importing countries, particularly on the part of developing countries [13]. When freezing technology became good enough to allow it, these trade barriers have not prevented the development of specialized processing for re-exports in third-party countries (Figure 2).[5]

To our knowledge, there is no tariff differentiation between wild and farmed products, although there are rules in some countries that require the consumers to be informed whether the fish is farmed or wild. The revisions of the HS-nomenclature were supposed to allow identification of aquacultured products for at least some countries and species, but this did not happen for the revision that is implemented in 2017 [37]. The next opportunity will be the revisions that will be implemented in 2023. Any trade policies that

[5] U.S. and China seafood trade data provide useful illustrations. Among the 2012 top 10 seafood products exported to China from the U.S. (by value) are pink salmon, chum salmon, and sockeye salmon, which are primarily wild-caught in Alaska and the Pacific Northwest. The third largest seafood import to the U.S. from China was salmon frozen filet that does not specify the species. Much of this product is likely of U.S. origin and processed in China, but the data do not allow one to make the connections directly. Also included in the top 20 imported products from China is Atlantic salmon frozen fillet. This product, in contrast, is almost certainly all farmed and produced in a third country (most likely Chile or Norway based on world production).

target specifically either aquacultured fish or wild-caught fish cannot have their intended effect if the HS-nomenclature does not expressly identify seafood trade according to production method. Because farmed and wild fish have many similarities, they are unlikely to be discernible by the average customs agent or consumer. Moreover, some argue that farmed versus wild is a false dichotomy anyway [38]. Thus, strict traceability systems must be in place for trade policies to have targeted effects on production practices. Without traceability, such differentiation will be rife with the same issues that affect tracing illegal, unmanaged and unreported (IUU) fish entering trade, and species mislabeling [39, 40]. Hence, unless appropriate systems are in place, it is not obvious that a separation between wild and farmed seafood in the HS-nomenclature would lead to welfare-improving trade. It is also possible that such a distinction could lead to increased use of protectionist measures.

4.2 Subsidies

Fisheries subsidies around the world have been well studied. Following a World Bank report [41] that estimated that fisheries subsidies made up 30-35% of total cost, there has been significant attention to this issue [42, 43]. Other, researchers have estimated the magnitude of subsidies for particular regions such as the North Atlantic [44] and globally [45], while subsidies in aquaculture have received limited attention in the literature. However, aquaculture products figure prominently in anti-dumping cases involving seafood, and there is a subsidy element in many of the complaints. For instance, when Norway was found guilty of dumping salmon in the US in 1992 [46], a part of the complaint involved subsidies. These came in two forms: a regional preference scheme where all companies in the northernmost part of Norway paid a lower payroll tax, and a public rural community bank that provided capital at subsidised cost. There are similar schemes in a number of developed countries, and subsidies for investment and regional development are prevalent, particularly in the EU. However, most of these countries are large net importers of seafood such that subsidized aquaculture is not a trade issue. Still, these subsidies potentially reduce imports from developing countries.

The prevalence of aquaculture species in anti-dumping conflicts is an indication of the importance of increased aquaculture production in the expanding global seafood trade.[6] That the two most valuable farmed species, salmon and shrimp, show up most often in anti-dumping cases reinforces this argument, although a number of other species have also been involved in anti-dumping cases.[7] Although such barriers may influence the development of the aquaculture industry in specific countries, it is not clear that they hinder the general trends, as illustrated by Keithly and Poudel [50] for the case of US anti-dumping actions against shrimp, for salmon [51] and catfish [52]. As aquaculture production of new species, and entry to new markets are likely to repeat these patterns, more trade conflicts are likely. Given that the use of anti-dumping cases has exploded after WTO prohibited tariff increases [53], it is likely that a large number of these anti-dumping cases related to aquaculture reflects protectionist measures or a repackaging of environmental concerns rather than addressing true trade-based grievances. That Norway and Chile largely where vindicated by WTO-panels after the long series of anti-dumping cases against salmon is one such example.

An interesting case that highlights many complexities of the global seafood trade is the U.S. anti-dumping action against shrimp from China, Vietnam, India, Thailand, Ecuador, and Brazil filed in 2003 [50]. The vast majority of U.S. imports from these countries came

[6] Tveteras [47] show how the seafood trade in Honduras is dominated by farmed shrimp and tilapia, while Asche and Bjørndal [17] show how seafood exports have increased in Norway and Chile due to salmon aquaculture.

[7] Kinnucan and Myrland [48, 49] and Keithly and Poudel [50] provide case studies for, respectively, salmon and shrimp.

from farmed shrimp. As such, an important basis for the case was that international organizations such as the World Bank allegedly subsidized the development of shrimp aquaculture in these countries and conferred an unfair competitive advantage on this growing export industry. Quantitatively assessing this claim is difficult. The production methods of shrimp farming and wild capture shrimp fishing differ dramatically, but to consumers the products are quite similar, especially once processed or frozen. The different production methods make it difficult to compare production costs of imports to the domestic product, which is a standard approach for determining liability in an anti-dumping allegation. The similarity of the product, however, means that farmed shrimp imports compete directly with domestic wild capture shrimp.

This case also presents some interesting equity issues. Suppose an international development organization encourages a country to develop a particular industry. Being successful in developing an export industry, the country could subsequently be punished with an anti-dumping duty, which is legitimated by another international organization, namely the WTO. Given the potential environmental impacts of fish farming, environmental NGOs and development organizations may provide technical support and financial incentives for developing countries to farm fish more sustainably. Will these actions be seen as subsidies and grounds for anti-dumping duties allowed by the WTO?

4.3 Non-tariff barriers

Non-tariff barriers are a difficult case because they are often perceived differently by the involved parties. For importing countries, they are perceived as a necessary means to protect public health or to inform consumers. There are several cases that seem to conform to this perspective. Some aquacultured fish from China were found to contain chemicals including malachite green that apparently had been introduced in the feeding process [54]. However, there are also a number of exporters who think these requirements are a new form of trade barriers. The experiences of Kenyan exporters of Nile perch and Bangladeshi shrimp exporters are examples. For some periods, imports to the EU were terminated by the EU due to food safety concerns. The EU Commission claims that import bans were entirely justified. The same is true for salmon from Norway and pangasius from Vietnam to Russia. In the same way as the majority of anti-dumping cases involving seafood is related to aquaculture, this also seem to be the case for food-safety related non-tariff barriers, although it is very hard to document.

4.4 Non-governmental efforts to promote marine conservation

NGOs generally have not been satisfied with the track records of governments, trade policy, international agreements, and international organizations to promote marine conservation. Overfishing due to open access and the deleterious effects of fishing on marine biodiversity and unique marine habitats persist in many parts of the world, as well as the negative impacts of aquaculture production on surrounding ecosystems. As a result, NGOs have started to advocate for using the market to influence fisheries management and marine conservation and ecosystem health through consumer participation in the market for seafood (as distinct from market-based regulations like catch shares). Some NGOs claim that consumers do not accept the mismanagement of fish stocks or aquaculture's impacts on the environment, and wish to purchase sustainable seafood alternatives. While these approaches do not currently fall into a category of formally recognized non-tariff trade barriers, certification and labelling as required by governments may fall under the TBT agreement of the WTO. An interesting question is to what extent are some of these programs approaching *de facto* non-tariff barriers?

For example, ecolabeling is one market-based tool, allowing consumers to choose seafood only from well managed fisheries.[8] To strengthen the credibility of ecolabels, these programs often also require third-party certification. The most notable certification body is the Marine Stewardship Council (MSC), which has certified a number of fisheries as meeting their standards for sustainability, and the Aquaculture Stewardship Council (ASC) which is increasing its presence in certification of aquaculture best practices. There are also other ecolabels for farmed fish, for example, the Friend of the Sea and NaturLand are available for both wild and farmed seafood [57]. Economic incentives for ecolabeling include increased opportunities to enter higher-valued markets, and potentially higher ex-vessel prices [58-61].

Use of an ecolabel will in most cases also require some form of traceability to ensure that fish with the right to bear an ecolabel is not mixed with non-certified fish in the supply chain. As discussed above, traceability is also a necessary condition for the use of trade policy to facilitate environmental outcomes. What is distinct in the case of ecolabeling is that if the labelled product is sufficiently differentiated to encourage better environmental practices, then only the labelled fish requires traceability. Trade policy, in contrast, would require traceability for all fish, a much higher hurdle.

Developing countries in particular have difficulties in meeting MSC- or ASC-type standards [62]. More recently, in order to meet growing commitments by retailers in developed countries to source only sustainable seafood, fisheries improvement project

[8] Roheim [55] and Ward and Phillips [56] provide a useful review of environmental groups' influences in markets for sustainable seafood and ecolabeling in practice.

(FIPs) and aquaculture improvement projects (AIPs) have become increasingly prevalent. With a goal of putting fisheries or aquaculture on a path to sustainability, possibly leading to certification, FIPs and AIPs use the supply chain to provide incentives for continual improvements [59, 63]. Globally, retailers source seafood based upon criteria that fish come from certified fisheries and aquaculture, or from those engaged in credible FIPs and AIPs [63].

Such differentiation between 'sustainable' and not -- though certification, labelling, or improvement projects -- serves to segment the global market. Meeting the standards requires that producers provide information that otherwise might not be provided and carry out costly additions to the production processes they otherwise might not undertake. These burdens make some producers unable or unwilling to meet the standards and therefore further segments the market, reduces trade, or changes the trade patterns. While some standards seem justified, the myriad of requirements that differ across countries creates a barrier for many producers. This is particularly true for producers in developing countries, where limited infrastructure makes it very hard to document the production process even if it is compliant. The problem is particularly acute for ecolabeling, as many developing countries lack the governance structure for their producers to be certified. However, at the other end of the labelling spectrum, it is difficult to draw a clear distinction between a generic brand that focuses on promoting an attribute of the product, and a company brand that promotes certain attributes of the seller. Hence, if one were to implement measures that prohibit some voluntary labels because they are distorting trade, it is difficult to identify the point where labelling should not be allowed without outlawing all labels. In essence, there is a fine line between labelling and branding.

7. Conclusions and recommendations

One cannot assign causality for the growth of aquaculture to international trade. However, the fact that the global seafood trade continues to grow despite the stagnation of wild harvests is a strong indication that a substantial part of aquaculture is trade driven. As always, this creates winners and losers. Among the losers are local seafood consumers who lose in the competition with the global market, people who lose their livelihoods when aquaculture producers take over communal lands, and producers of other foods in importing countries who cannot compete. In aggregate, societies will be better off with economic growth, although there can be negative distributional consequences.

That aquaculture products are highly traded implies that trade measures theoretically can be effective in changing behaviour for whatever reason they are implemented. The substantial negative environmental impacts that have been documented in a number of cases suggest that trade policy is a tool that should be considered. However, aquaculture is not an inherently unsustainable production process in itself. Many of the sustainability concerns are local externalities, and attempting to regulate these externalities from importing countries arguably impinges on the sovereignty of exporting nations to regulate their own environments. Moreover, empirical examples of other environmental externalities suggest an Environmental Kuznets Curve should apply to aquaculture, and environmental outcomes may eventually improve as economic development progresses. To the extent that aquaculture production affects global public goods such as biodiversity, the use of trade policy brings up important equity considerations. Who should pay to preserve these global public goods? Will tariffs and non-tariff barriers disproportionately impose the incidence on developing countries when the largest share of benefits flow to wealthy, industrialized countries? We do not attempt to answer these questions but raise them as important context for aquaculture and trade policy.

Setting aside issues of sovereignty and equity with respect to global public goods, effective trade policy to address environmental concerns in aquaculture would need to address lack of local management. Unfortunately, production practices differ within country as they do across country and species. Hence, it is hard and most likely impossible to find general measures addressing the specific challenges, and at minimum an extensive and reliable traceability system would be required. The fact that aquaculture is a production technology that primarily is carried out in developing countries adds to the traceability challenges and decreases the likelihood that trade policies would attain their desired outcomes. The rapid growth in production is an indication that it contributes to economic growth and development. Poorly directed trade measures will then primarily contribute more trade barriers and impede economic development in developing countries. The positive health effects of consuming seafood further contribute to the positive effects of increased aquaculture production and trade. Poorly targeted trade policy could then undermine public health by inadvertently decreasing the amount of seafood consumed. Aquaculture can also have positive environmental effects in a large picture, as higher food production from aquatic environments are likely to reduce pressure on marginal terrestrial lands for food production [64]. If trade measures are to be implemented, they need to focus on specific environmental or management issues. More general measures are, if they are effective, only likely to reduce food production and economic growth in a number of developing countries.

References

1. Asche, F., Bellemare M, Roheim CA, Smith MD, Tveteras S. Fair Enough? Food Security and the International Seafood Trade. World Development 2015; 67: 151-160.

2. Anderson JL, Asche F, Tveterås S. World Fish Markets. In Handbook of Marine Fisheries Conservation and Management, in Handbook of Marine Fisheries Conservation and Management, Grafton RQ, Hilborn R, Squires D, Tait M, Williams M. Eds. 2010, Oxford University Press: Oxford.

3. Smith MD, Roheim CA, Crowder LB, Halpern BS, Turnipseed M, Anderson JL, Asche F, Bourillón L, Guttormsen AG, Kahn A, Liguori LA, McNevin A, O'Connor M, Squires D, Tyedemers P, Brownstein C, Carden K, Klinger DH, Sagarin R, Selkoe KA. Sustainability and Global Seafood. Science, 2010; 327: 784-786.

4. Asche F, Roheim CA, Smith MD. Markets, Trade and Seafood, in Encyclopedia of Natural Resources. Wang YQ. Ed. 2014; Taylor & Francis: New York.

5. Tveterås S, Asche F, Bellemare MF, Smith MD, Guttormsen AG, Lem A, Lien K, Vannucini S. Fish Is Food - The FAO's Fish Price Index. PLoS One. 2012; 7: e36731. doi:10.1371/journal.pone.0036731.

6. FAO. The state of world fisheries and aquaculture 2014. 2014; Rome: FAO.

7. Anderson JL. Aquaculture and the Future. Marine Resource Economics. 2002; 17: 133-152.

8. Asche F. Farming the Sea. Marine Resource Economics. 2008; 23: 507-527.

9. Delgado C, Wada N, Rosengrant MW, Meijer S, Ahmed M. Fish to 2020: Supply and Demand in Changing Global Markets. 2003; Washington: IFPRI.

10. WorldBank. Fish to 2030: Prospects for Fisheries and Aquaculture. 2013; World Bank Report number 83177-GLB: Washington, D.C.

11. Naylor RL, Goldburg RJ, Mooney H, Beveridge M, Clay J, Folke C, Kautsky N, Lubchenco J, Primavera J, Williams M. Nature's Subsidies to Shrimp and Salmon Farming. Science. 1998; 282: 883-884.

12. Naylor RL, Goldburg RJ, Primavera J, Kautsky N, Beveridge M, Clay J, Folke C, Lubchenco J. Effects of Aquaculture on World Fish Supplies. Nature. 2000; 405: 1017-1024.

13. Roheim, C.A. Trade Liberalization in Fish Products: Impacts on Sustainability of International Markets and Fish Resources. In Global Agricultural Trade and Developing Countries. Beghin AA. Ed. 2004; World Bank: Washington, DC.

14. Asche F, Hansen H, Tveteras R, Tveteras S. The Salmon Disease Crisis in Chile. Marine Resource Economics. 2009; 24: 405-411.

15. Asche F, Roll KH, Sandvold HN, Sørvig A, Zhang D. Salmon Aquaculture: Larger Companies and Increased Production. Aquaculture Economics and Management. 2013; 17: 322-339.

16. Gordon DV, Bjørndal T. A Comparative Study of Production Factors and Productivity for Shrimp Farms in three Asian Conutries: Bangladesh, India, and Indonesia. Aquaculture Economics and Management. 2009; 13: 176-190.

17. Asche F, Bjørndal T. The Economics of Salmon Aquaculture. 2011; Oxford: Blackwell.

18. Barrett CB, Bachke ME, Bellemare MF, Michelson HC, Narayanan S, Walker TF. Smallholder Participation in Contract Farming: Comparative Evidence from Five Countries. World Development. 2012; 40: 715-730.

19. Bellemare MF. As You Sow, So Shall You Reap: The Welfare Impacts of Contract Farming. World Development. 2012; 40: 1418-1434.

20. Asche F, Bjørndal T, Young JA. Market Interactions for Aquaculture Products. Aquaculture Economics and Management. 2001; 5: 303-318.

21. American Heart Association (AHA). Sudden Cardiac Death. 2012; http://newsroom.heart.org/news/american-heart-association-and-236771 (last accessed March 2014).

22. Mozaffarian D, Rimm EB. Fish Intake, Contaminants, and Human Health: Evaluating the Risks and the Benefits. Journal of the American Medical Association. 2006; 296: 1885-1899.

23. National Academy of Sciences, Institute of Medicine. Seafood Choices: Balancing Benefits and Risks. 2006; Accessed at http://newton.nap.edu/catalog/11762.html.: Washington, DC.

24. USDA and HHS. Dietary Guidelines Advisory Committee. 2005; Accessed at www.health.gov/dietaryguidelines;dga2005/report/. Dietary Guidelines Committee.

25. Santerre C. The Risks and Benefits of Farmed Fish. Journal of the World Aquaculture Society. 2010; 41: 250-257.

26. IOM (Institute of Medicine) and NRC (National Research Council). A framework for assessing effects of the food system. 2015; Washington, DC: The National Academies Press.

27. Hites RA, Foran JA, Carpenter DO, Hamilton MC, Knuth BA, Schwager SJ. Global Assessment of Organic Contaminants in Farmed Salmon. Science. 2004; 303: 226-229.

28. Sha S, Santos JI, Roheim CA, Asche F. Media Coverage of PCB Contamination of Fresh Farmed Salmon: The Response of U.S. Import Demand. Forthcomming in Aquaculture Economics and Management, 2015.

29. Teutsch SM, Cohen JT. Health Trade-offs from Policies to Alter Fish Consumption. American Journal of Preventative Medicine. 2005; 29: 324-329.

30. Cohen JT, Bellinger DC, Connor WE, Kris-Etherton PM, Lawrence RS, Savitz DA, Shaywitz BA, Teutsch SM, Gray GM. A Quantitative Risk-Benefit Analysis of Changes in Population Fish Consumption. American Journal of Preventative Medicine. 2005; 29: 325-334.

31. Willett WC. Fish: Balancing Health Risks and Benefits. American Journal of Preventive Medicine. 2005; 29: 321-322.

32. Torrissen O, Olsen RE, Toresen R, Hemre GI, Tacon AGJ, Asche F, Hardy RW, Lall SP. Atlantic Salmon (Salmo salar) - The Super-Chicken of the Sea? Reviews in Fisheries Science. 2011; 19: 257-278.

33. Tveteras S. Norwegian Salmon Aquaculture and Sustainability: The Relationship between Environmental Quality and Industry Growth. Marine Resource Economics. 2002; 17: 121-132.

34. Asche F, Oglend A, Tveteras S. Regime Shifts in the Fish Meal/Soybean Meal Price Ratio. Journal of Agricultural Economics. 2013; 64: 87-111.

35. Kristofersson D., Anderson JL. Is there a relationship between fisheries and farming? Interdependence of fisheries, animal production and aquaculture. Marine Policy. 2006; 30: 721-725.

36. Norwegian Directorate of Fisheries. 2015.

37. World Customs Organization. International Convention on the Harmonized Commodity Description and Coding System: Amendments to the Nomenclature appended as an Annex to the Convention accepted pursuant to the Recommendation of 27 June, 2014. 2014; Brussels.

38. Klinger D, Turnipseed M, Anderson JL, Asche F, Crowder L, Guttormsen AG, Halpern BS, O'Connor M, Sagarin R, Selkoe KA, Shester G, Smith MD, Tyedmers P. Moving Beyond the Fished or Farmed Dictomy. Marine Policy. 2013; 38: 369-374.

39. LeGallic B, Cox A. An economic analysis of illegal, unreported and unregulated (IUU) fishing: Key drivers and possible solutions. Marine Policy. 2006; 30: 389-695.

40. Stokke OS. Trade measures and the combat of IUU fishing: Institutional interplay and effective governance in the Northeast Atlantic. Marine Policy. 2009; 33: 339-349.

41. Milazzo, M. Subsidies in World Fisheries. WorldBank Technical Paper no. 406. 1998: WorldBank: Washington.

42. OECD. Subsidies: A way towards a sustainable fisheries? 2005; Organization for Economic Cooperation and Development: Paris.

43. OECD. Financial Support to Fisheries. Implications for Sustainable Development. 2006; Organization for Economic Cooperation and Development: Paris.

44. Munro GR, Sumaila UR, Subsidies and their potential impact on the management of the ecosystems of the North Atlantic. Fish and Fisheries. 2002; 3: 233-250.

45. Sumaila UR, Khan A, Andrew J, Dyck A, Watson R, Munro G, Tyedmers P, Pauly DA. Bottom up re-estimation of global fisheries subsidies. Journal of Bioeconomics,. 2010; 12: 201-225.

46. Anderson JL. Salmon Market Dynamics. Marine Resource Economics. 1992; 7: 87-88.

47. Tveteras S. Price Analysis of Export Behavior of Aquaculture Producers in Honduras and Peru. Aquaculture Economics and Management. 2015; 19: 125-147.

48. Kinnucan HW, Myrland Ø. The Relative Impact of the Norway-EU Salmon Agreement: A Mid-term Assessment. Journal of Agricultural Economics. 2002; 53: 195-220.

49. Kinnucan HW, Myrland Ø. Free-Rider Effects of Generic Advertising: The Case of Salmon. Agribusiness: An International Journal. 2003; 19: 315-324.

50. Keithly Jr. WR, Poudel, P. The Southeast U.S.A. Shrimp Industry: Issues Related to Trade and Antidumping Duties. Marine Resource Economics. 2008; 23: 439-463.

51. Asche F. Testing the effect of an anti-dumping duty: The US salmon market. Empirical Economics. 2001; 26: 343-355.

52. Norman-López A, Asche F. Competition between imported Tilapia and US catfish in the US market. Marine Resource Economics. 2008; 23: 199-214.

53. Prusa TJ. The Trade Effects of U.S. Antidumping Actions. In Effects of U.S. Trade Proctection and Promotion Policies, RC Feenstra, Ed. 1996; University of Chicago Press: Chicago.

54. Broughton EI, Walker DG. Policies and practices for aquaculture food safety in China. Food Policy. 2010; 35: 471-478.

55. Roheim CA. An Evaluation of Sustainable Seafood Guides: Implications for Environmental Groups and the Seafood Industry. Marine Resource Economics. 2009; 24: 301-310.

56. Ward T, Phillips B. Seafood Ecolabeling: Principles and Practice. 2008; Oxford: Wiley-Blackwell.

57. Parkes G, Young JA, Walmsley SF, Abel R, Harman J, Horvat P, Lem A, MacFarlane A, Mens M, Nolan C. Behind the Signs—A Global Review of Fish Sustainability Information Schemes. Reviews in Fisheries Science. 2010; 18: 344-356.

58. Blomquist J, Bartolino V, Waldo S. Price Premiums for Providing Eco-Labelled Seafood: Evidence from MSC-Certified Cod in Sweden. Forthcomming in Journal of Agricultural Economics. 2015.

59. Deighan LK, Jenkins LD. Fishing for recognition: Understanding the use of NGO guidelines in fishery improvement projects. Marine Policy. 2015; 51: 476-485.

60. Roheim CA, Asche F, Insignares JS. The Elusive Price Premium for Ecolabelled Products: Evidence from Seafood in the UK Market. Journal of Agricultural Economics. 2011; 62: 655-668.

61. Wakamatsu, H. The Impact of MSC Certification on a Japanese Certified Fishery. Marine Resource Economics. 2014; 29: 55-67.

62. Bush S, Toonen H, Oosterveer P, Mol AHJ. The ‘devil’s triangle’ of MSC certification: Balancing credibility, accessibility and continuous improvement. Marine Policy. 2013; 37: 288-293.

63. Sampson GS, Sanchirico JN, Roheim CA, Bush S, Taylor E, Allison E, Anderson JL, Ban N, Fujita R, Jupiter S, Wilson JR. Secure Sustainable Seafood from Developing Country Fisheries: Require improvements as conditions for market access. Science. 2015; 348: 504-506.

64. Hilborn R. Environmental cost of conservation victories. Proceedings of the National Academy of Sciences. 2013; 110: 8393-8398.

Captions

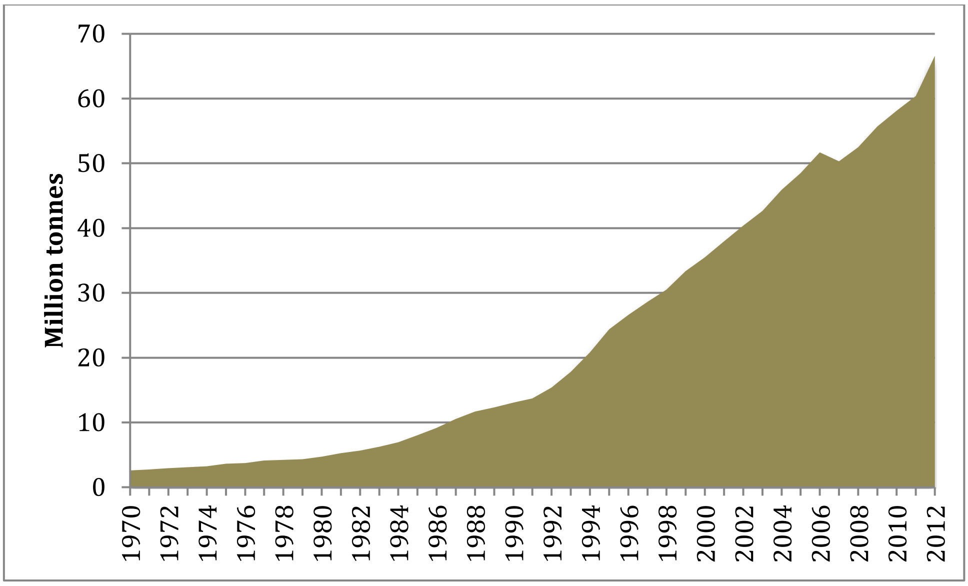
Figure 1. Global aquaculture production

Source: FAO [6]

Figure 2 The Complexity of the Modern Seafood Trade. For just a single seafood producer with two trading partners, the possible paths for seafood through trade and processing to end consumption proliferate dramatically.

Figure 3. Norwegian salmon production and antibiotics use

Source: [36]



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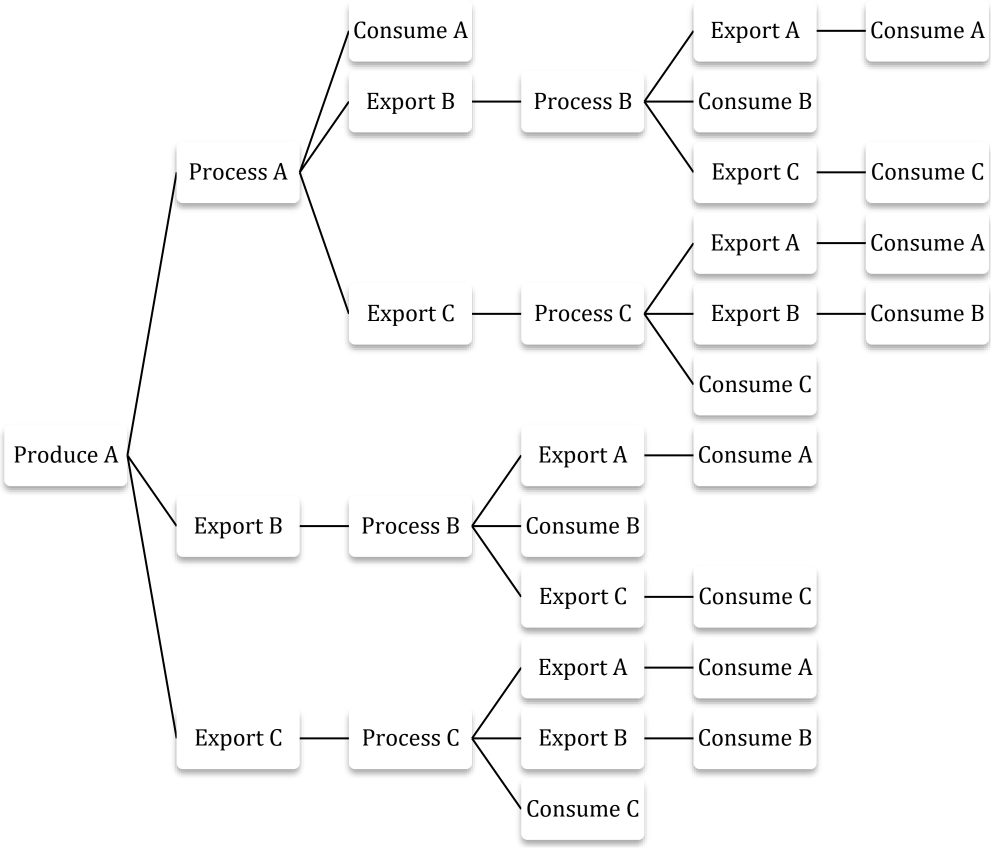
Source: FAO [6]



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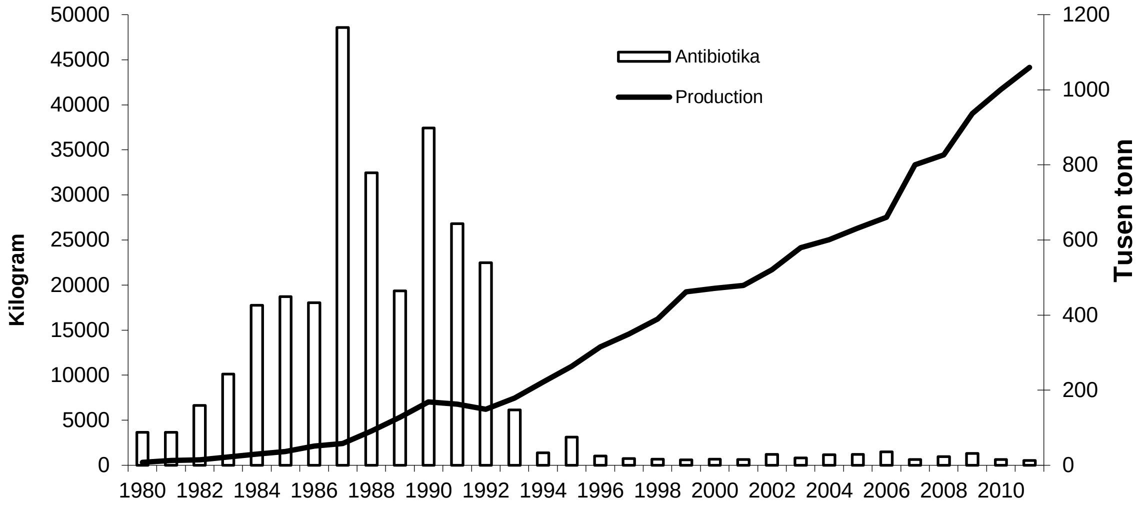

Figure 3. Norwegian salmon production and antibiotics use

Source: [36]