Session 3: Advantages and opportunities

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Globalization and the impact of aquaculture

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ABSTRACT

The comments presented are motivated mainly by the results of a recent workshop sponsored by the Organisation for Economic Co-operation and Development (OECD) Fisheries Committee on "Globalization and Fisheries," where "fisheries" included also aquaculture. The intent of the workshop was to explore those factors that would contribute best to maximizing opportunities being reaped from globalization and minimizing costs. Issues were examined across the value chain in order to maximize understanding of interactions of globalization with production, processing and distribution/markets/buyers/consumers. An integrated picture of some globalization challenges and opportunities is offered, alongside generic conclusions, with a view to their implications for aquaculture, as well as specific issues raised in aquaculture sessions, which may provide context in the light of globalization to some other aspects of the programme. Key messages resolve around observations on: the opportunities provided to aquaculture from the rise in demand for fisheries products; the paramount importance of sustainability/responsible production and high-quality regulation to all aspects of the value chain, as well as integration within it; perspectives on the role of hygiene and quality standards; priorities underlying investment and financing from the perspectives of these players; perspectives on the rise of ecolabels of various sorts; issues in enabling small-scale production into trade, especially in view of increasing concentration in the value chain; and other issues.

INTRODUCTION

This paper is intended to address the issue of globalization and its implications for opportunities in aquaculture. There are many papers at the Conference that show such opportunities on the basis of case studies, including the potential economic and community impacts this will provide as a result. This paper provides some generic policy insights on this issue from an examination of how globalization can affect fisheries, including aquaculture.

Indeed, "globalization" is a key context underlying most current policy discussions in fisheries – which, in this paper, include both capture and aquaculture fisheries. Globalization is a concept that implies a "system" of complex linkages among international participants, including states – a system that needs to work effectively and responsibly. The challenges, opportunities and expectations accompanying increased

[1] Also Chairperson of a recent OECD-FAO Workshop on Globalization and Fisheries, which, in part, informs this paper. All opinions are those of the author and reflect neither the Government of Canada nor the OECD Committee on Fisheries

globalization are at the root of some of the most heated policy discussions taking place in fisheries.

Opinions differ on whether globalization is a positive or negative factor in the world economy and community, where these opinions vary according to whether one is facing perceived opportunities or risks from it. The overall goal for the global community should be to understand the policy, governance and other changes needed so that the benefits of globalization can be maximized and risks minimized or managed.

As for aquaculture, this paper takes the point of view that there are many opportunities for responsible aquaculture, especially for developing countries, and especially in light of challenges currently facing capture fisheries, but less so where it is not responsible or not perceived as responsible.

Moreover to a large extent, at least reputationally, the fortunes of aquaculture and capture fisheries are inextricably linked (such as in competition with other food sectors), and both need to be sustainably managed – and perceived to be so – in order to maximize the benefits to both.

This paper also reports on views that globalization can potentially induce a "race to the top" in terms of sustainability and responsibility, if all players in the fisheries value chain work together coherently and capacity building is a major part of the system. This is true for aquaculture as it is for capture fisheries.

In this respect, responsible markets are also as important as responsible producers, on two fronts. On one hand, unjustifiable market standards can impede the functioning of the global system, especially if technology transfer and capacity building are weak, leading to a number of dynamics and lack of buy-in to shared gains of more responsible fisheries. Similarly, large markets that provide an outlet for irresponsibly produced product (whether capture fisheries or aquaculture) to find a way around global norms will undermine the benefits of globalization for all.

UNDERSTANDING GLOBALIZATION

There are no doubt numerous formal definitions of globalization, many of which would reflect an increasing interdependence of markets and citing increased trade flows. This paper urges a broader view of the concept, in order to induce a consideration of a broad set of linkages and spillovers that should be taken into account. Overall, the point of view taken here is that globalization is a force that is creating an ever larger *community of joint interest*, which can go beyond concepts such as increased trade.

Some factors that indicate increasing interdependence among global players – including states – include, for example:

- integration and interdependence (i.e. linking together) of markets and players;
- increased mobility of inputs (e.g. labour and capital);
- freer flows of goods, services and investment;
- increased "reach" of sophisticated transportation and logistics;
- increased transfer of technology and knowledge;
- freer flows of information of all kinds;
- increased linkages and spillovers among activities and issues (both benefits and risks);
- spread of ethical and/or cultural changes and aspirations;
- shared global threats that need cooperative solutions (e.g. climate change, disease, fisheries sustainability, other environmental threats); and
- rise of global institutions dealing with cross-border issues as well as harmonization of domestic policies.

This list is not exhaustive, nor are the items noted mutually exclusive. However, the key point is that they emphasize the *connections between activities and incentives that will cause spillovers from individual agents and states into the broader global community*.

Several papers at this Conference have described how global demand and relationships for fisheries products are changing, including increased global reliance on aquaculture products. The emerging picture from available data regarding changes in production and trade flows is quite clear, including from the FAO's annual *Status of Fisheries and Aquaculture*, and will not be repeated here. It is clear from the preceding illustrative list that such data cannot, however, tell the whole story about the increased complexity of linkages brought about by increased globalization or suggest solutions that will need to be considered, if increased globalization in fisheries is to be managed to maximum benefit[2].

The Organisation for Economic Co-operation and Development (OECD) is an international institution devoted to improving analysis, policy making and "governance" (defined here as the body of law, regulations and decision-making mechanisms) of its member states and increasingly, the broader global community. Similar to other OECD policy committees, the OECD's Committee for Fisheries (OECD-COFI) does analytical work on major issues affecting fisheries that are important to improving domestic polices and governance, engages in policy debate and makes recommendations on policy needs and reform, both for use of domestic policy-makers and by the broader international community. It is hoped that the analytical work of the OECD-COFI will help provide an analytical foundation to broader international debates.

As part of its programme of work, the Committee is undertaking a large project on globalization and fisheries[3] to better understand that which is needed to make the global "system" work better and ensure a wider sharing of its benefits.

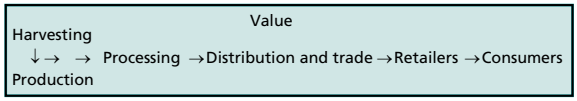
As part of the OECD-COFI globalization work programme, the fisheries departments of the OECD and the FAO, alongside the Committee, recently co-sponsored a workshop on this issue, which brought together over 100 experts in all domains to share views on the topic of globalization and fisheries, including aquaculture (involving, for instance, producers/harvesters, processors, buyers, retailers, government decision-makers). Some high-level observations arising out of these discussions inform, in part, observation in this paper.

A SIMPLIFYING FRAMEWORK: DECOMPOSING IMPACTS OF GLOBALIZATION

As noted, globalization can give rise to a complex set of relationships. A simplifying paradigm can organize our thinking about how globalization affects fisheries and ensure a balanced approach to the issue, rather than just focussing on high-profile issues.

One way is to use as a guide, the stages of production and activity. The "value chain" illustrated in Figure 1 shows the stages at which "value" is added to a product as it is transformed to meet a market need. Value-added increases as one moves from left to right in this chain. The illustration shown in this diagram is very simplified. For instance it does not include the tertiary sector – or related services – spawned by higher-value activities at points throughout the chain, but it is illustrative of a framework that can be used to examine the impacts of globalization in a complete way.

FIGURE 1
Value chain



In Figure 1, the fishing value chain starts on the left, with both harvesting and aquaculture

[2] Moreover, even within economic data, new forms of industrial/corporate organization arising from globalization – including out-sourced production and re-exports, for example – are likely challenging official statistics to tell the whole story of increased economic interdependence.

[3] "Globalization" is also a broader cross-cutting topic at the OECD, intended to be addressed by a number of its policy committees.

"production", and together these products move through to processing. The product is then consumed locally or distributed or traded into markets (sometimes back into production as feed), while some products go to retailers and then to consumers. One can examine globalization impacts on the value chain to better understand:

- the impacts of globalization at each level of activity;
- the linkages up and down the chain from producers to consumers and vice versa; and
- the policy, institutional practices and governance needs at each stage in the value chain in order to maximize benefits and minimize risks of globalization.

That is the goal of the OECD-COFI globalization project. The agenda of the OECD-FAO Globalization Workshop, referenced above, was also organized with such a framework in mind, in order to best organize information and feedback from each community of interest. That workshop did not focus specifically on aquaculture, other than through one specialized session. However, broad lessons from that workshop inform the issue of aquaculture opportunities.

AQUACULTURE IN THE FISHERIES VALUE CHAIN

Before examining the implications of globalization for opportunities in aquaculture, it is important to reflect on how aquaculture generally fits in this picture. Generally, aquaculture and capture fisheries (harvesting) can be considered as distinct activities at the "production" end of the chain, each with its own challenges, but they are often linked (such as feedstock for some species or price changes induced by one activity, such as higher aquaculture production, which can have an impact on production in the other).

However, after these products enter processing, and further to consumers, the source of production can be quite unclear (e.g. consumers may simply consider "fish as food"), and fisheries products from both sources may find their greatest competition from other food products. Thus, whether aquaculture products are consumed depends on a broader set of issues, such as the attractiveness of fish overall (reputation), availability of attractive alternatives, culture and whether consumers trust it and like it. Aquaculture and capture fisheries have joint/mutual interests at the consumption stage, in particular. Thus it is unhelpful, and probably misguided, to consider aquaculture and capture fisheries as "competitors" for consumer attention. However, they do occupy different niches – with differing strengths – in the global value chain, as will be illustrated below.

Some aquaculture activities are aimed only at satisfying basic local needs, similar to artisanal fisheries. But those facing global or regional markets will be trying to gain as much value as possible. We know states want to move beyond just producing lower-value raw materials, with the gains of higher-value activities accruing only to other economies. They want to encourage higher-value activities into their own economies (processing and related services), as it is in the secondary and tertiary activities where income and jobs are greatest. The global challenge is, in one respect, the competition for access to both resources and those higher-value activities.

Sometimes production activities where margins are lowest search for short-term gains through rapid exploitation, lower regulation etc to reduce costs (e.g. illegal, unreported and unregulated (IUU) fishing, race for fish, less responsible aquaculture). Sometimes these activities take place where capacity for strong governance and management is relatively lower. Higher-value activities, however, search for low commercial risk. That is both the challenge and the opportunity for global fisheries, including aquaculture.

Some important general observations from recent OECD-FAO discussions of globalization

Is globalization providing real opportunities? As noted, the debate on globalization as "good" or "bad" depends perhaps on where one sits. Overall, while the above-

referenced workshop did not shy away from issues and challenges, it was markedly positive about globalization, in general.

Globalization will provide opportunities for a wide set of players, providing that certain conditions – most notably responsibility and sustainability – are met. It will be the responsibility of all, including both producers and markets, to ensure that these benefits accrue in a sustainable, resilient and inclusive global system.

In relation to discussions about capture fisheries, it could be said that the aquaculture session was the most positive about the potential gains from globalization. There are challenges to be faced, especially for small-scale producers in Africa and Asia. But important initiatives are underway to overcome these, especially in Asia – including through important partnerships and networks (such as the Network of Aquaculture Centres in Asia-Pacific (NACA) in Asia, and with new aquaculture cooperation networks also starting up in the Americas and Africa) to solve problems, build capacity and share technical knowledge; provide new forms of financing; and new ways of organizing ("clustering") small-scale producers to give them more collective market power.

The issues facing wild fisheries were, in contrast, somewhat more difficult. All fishing states want more from capture fisheries, while opportunities there are diminishing. It takes a strong capacity to properly control fleets, manage common resources wisely (especially when international governance is often weaker than it should be), and to take part actively in international cooperation and collaboration, especially for high-seas issues. Some fishing and trade arrangements are also accused, by some, of preventing developing countries from earning adequate value from capture fisheries. There is a clear advantage in capture fisheries for developed states or those with strong management and governance capacity. Capture fisheries can be hard for new small players, where capacity to exploit and manage capture fisheries may be low, and/or where fishing allocations in high seas may not have been secured.

Increased global demand can undermine fisheries and ecosystem sustainability and the environment unless fisheries are well regulated (including enforcement). If not, this undermines gains for all in the global community[4].

As this paper is focussing on opportunities, this can be restated to say that if the global community wishes to exploit that which globalization has to offer, it is best done by using resources sustainably and ensuring wider ecosystem and environmental sustainability.

Globalization was viewed as also encouraging and enabling responsible production, as the global community finds ways to work together to link demand and supply. For instance, most major markets are in developed states, and increasingly, production will be coming from developing states. Despite well-known challenges for developing states, the workshop (which included many developing-country representatives) took a positive view overall of the merit of health and safety standards, given the realities of demand in major markets that place a high premium on safety and security of food products generally. It was noted that reforms being undertaken to meet these standards and associated capacity building are enabling products to enter more markets than without these standards. There are interesting examples from Africa and Asia, for example, about what can and is being done to enable products to meet exacting standards in developed country markets. The issues raised were more in their application, stability, predictability and transparency, not in their existence *per se*.

And for both harvest and aquaculture fisheries, there are a large and increasing number of nongovernmental players who have resources, tools and influence. Their strengths and knowledge, and resources and information need to be harnessed to help ensure such standards do not provide an unnecessary obstacle to globalization.

[4] Indeed, concern over this risk is the basis of some key debates in the World Trade Organization (WTO) – subsidies discussions and, in some cases, market access.

Specific impacts of globalization throughout the value chain, and implications for aquaculture

Production

Numerous papers have described how rising global demand for fish and seafood cannot be met from harvest fisheries alone. Responsible aquaculture will need to fill the gap. Most capture fisheries are fully subscribed, some fisheries are depleted and need to be recovered, and overall, global harvesting capacity and effort must be reduced from current levels to assure fish stocks stay healthy. Vulnerable ecosystems are also being increasingly protected, which may result in a reduction in fishing opportunities.

As for the number of fishers and income and community needs, similarly, fewer fishers, not more, are needed globally in order to ensure that employment is durable and viable. Moreover, because of lower returns, many capture fisheries are in a cost-price squeeze (especially as energy costs increase), which further inhibits the ability of weak elements of the sector to add substantially to community well being.

Aquaculture can fill the gap of rising demand over the longer term, and make a substantial contribution to income jobs and community well-being, but only if certain conditions are met, so product can get to, and is accepted in markets, and the environment is preserved to allow it to endure. We need to have learned some lessons from wild fisheries in this respect.

Some aquaculture-related activities can assist fisheries or help replace important or iconic fisheries products that have been depleted (e.g. cod) and reach isolated communities in the way that other economic activities might not.

Aquaculture in developing countries may thus face particular opportunities, especially as it can be large scale or small scale[5], and thus suitable for various contexts.

In developed economies, aquaculture growth is levelling off and may not fulfil the potential foreseen in the recent decade. Several developed states, including in Europe, Canada and the United States are re-evaluating policies to reinvigorate the sector, but generally they may not fulfil as large a share of the fisheries products gap filling as earlier foreseen:

- developed countries are generally higher-cost producers and find it increasingly difficult to compete with high-quality lower-cost production;
- some developed countries are facing issues related to securing sites for aquaculture due to increased competition for oceans space (including from non-use);
- aquaculture has faced reputational issues in some states, which in some cases, have caused moratoria from community backlash over environmental/ecosystem risk (sometimes reflecting the effects of active environmental nongovernmental organizations (ENGOs) who highlight environmental and resource risks associated with aquaculture); and
- other alternatives for economic and rural development may be available in developed countries as well, altering perceptions on the balance of risk where it is perceived and lessening the pressure on aquaculture as the sole provider of jobs and income. Activities may focus as well on higher-value activities, including processing and services (see below under processing) sourcing product from other areas.

Processing

Processing is an important provider of jobs and income, especially for women. Processing is the part of the value chain where integration – especially vertical integration among firms – really begins[6]. However, a race for jobs, and subsidies to harvesting or processing to encourage jobs and income, can lead to processing overcapacity that can

[5] And financing and marketing/distribution options for small scale operations are increasingly available

[6] Very few large firms are integrated into the harvesting sector, except in cases where harvesting is very well managed, generally including the use of market-based measures such as individual or enterprise quotas.

filter down the value chain to encourage overproduction and environmental risk, as firms need raw material to earn a return on investment. This may lead to taking risks in aquaculture that might not otherwise have been induced.

Processors taking part in the workshop – and the financiers who provide the investment capital – continually emphasized their need for sustainable supplies of fish and their increasing unwillingness to take on or maintain a large amount of commercial risk. In fact, reducing those risks, especially in public companies, is leading to consolidation in the processing sector. The global value chain as relates to large markets in developed countries is becoming quite concentrated in large public companies. It is this protection of shareholder risk, in public companies, that prevents processors from investing in harvesting unless it is extremely well managed. In any case, for companies large and small, earning a return on investment drives processors increasingly to be searching for reliable and diversified sources of supply.

Increasingly, large integrated processors are explicit in saying they are sourcing their raw material from a wide variety of global – not national – fisheries. Technology and technology transfer better supports the complicated logistics of preservation of product quality, and more countries are meeting necessary standards as well.

In fact, many developed-country processors are moving into tertiary activities, exporting and re-importing products to and from lower-cost processors, and also earning returns from brokering activities, where quality and cost advantages make sense. In Canada, some processors say some "Canadian" product never actually enters the country.

Aquaculture has a number of assets that potentially situate it advantageously in relation to processor demand. These assets include predictable and uniform supply, and more even quality. This allows processing plants to run more effectively, reduce costs and risk, and achieve higher prices due to higher quality. Many wild fisheries – especially less-well-managed fisheries – have more difficulty in maximizing quality and timeliness (managing to market).

One of the major challenges facing aquaculture relates to the small-scale aquaculture sector, where a challenge is to organize small-scale operations so that brokers and buyers can handle logistics and help product enter viable operations, domestically or especially internationally. A second challenge is the issue of sanitary and phytosanitary standards, and ensuring that product can meet necessary standards for relevant markets, and that in doing so, developing countries are not forced into creating a segmented production structure, with a formalized marginalized sector for local producers and communities whose products cannot access international markets – a cycle hard to break out of.

Trade and distribution

The trading system is traditionally viewed as the glue to global flows of inputs, products, services and investment. The trading system continues to face many challenges in fisheries, as for other products. Aquaculture and capture fisheries products are generally not distinguished in the trading system, and indeed are hard to identify in data.

Even though tariffs have fallen and in fisheries they are generally lower than in agriculture, large differences between bound and applied tariffs, tariff peaks on sensitive products in many countries, and tariff escalation (higher on processed product than raw product, to protect domestic processors) can distort the global production system. Tariff escalation will especially affect processing localization. Many argue that certain kinds of fisheries subsidies also both distort production and trade, as well as threaten sustainability of fisheries (especially capture fisheries), the environment, or both. The fisheries sector is also not immune from accusations of abuse of antidumping actions. Aquaculture can be particularly susceptible to the latter, and a number of antidumping actions have been taken against aquaculture products.

While current global, regional and bilateral negotiations on market access will further liberalize trade in fisheries products, it is also the case that this will reduce the advantage of existing tariff preferences for some developing countries and force their products to face greater competition.

Most fisheries-producing nations are now either in the World Trade Organization (WTO) or intending to accede, which will help take account of broader needs over time and provide mechanisms for settling disputes of many kinds. The Doha Development Agenda (DDA) is intended to help "level the playing field" for developing countries while improving the trading system.

Participants at the OECD-FAO workshop focussed mainly on the effects of high sanitary and phytosanitary standards. These are particularly important for aquaculture, especially in relation to contaminants and residues. As noted, the workshop revealed a common appreciation among developing countries' participants for the need for standards, and their role in having built buyer confidence in important markets for product from emerging producers. The real issues seemed to be, rather, in their implementation, variability and lack of transparency and mechanisms for capacity building and facilitation. As well, products can be recalled at borders, creating uncertainty and high transactions costs.

Fisheries can face serious reputational problems, ranging from sustainability and environmental impact to the issue of contaminants. These issues are common to both aquaculture and capture fisheries. Both sectors of the fishery are affected by the fragility of reputational gains that are made for both. A major border problem for an aquaculture product can have serious repercussions on reputation for all fisheries (capture and aquaculture) and vice versa, so quality and safety control matters critically to fish entering trade.

Trade facilitation is a large challenge, as entering markets is difficult for some producers, especially in developing countries. Some international standards are very high (e.g. against contaminants, and antibiotics), are close to zero tolerance (and with no prospects for change), and a great deal of technical know-how and production/processing surveillance is needed to ensure standards are met.

One advantage of aquaculture is its scaleability – it can be large intensive operations or small family-sized fragmented extensive operations. Access to trade and distribution is especially a challenge for small aquaculture operations, although it may be the case that product is trying to enter national or regional trade. However, new efforts at scaling up and "clustering" of very small aquaculture operations into larger operations/organizations are helping to overcome these impediments and ensure that the distribution system is more inclusive of all scales of producers.

As for emerging challenges: that which may be gained in formal trade liberalization and formal trade facilitation to meet states' technical standards may now be being challenged by needs of private standards – especially for sustainability. The issue of ecolabelling is increasingly part and parcel of issues concerning access of products to markets (see below under *Consumers* for a more detailed discussion. Ecolabels will facilitate access to markets for those fisheries capable of being certified. However, at this time, formal ecolabels are only available for capture fisheries, and information-rich ones at that.

The actual trading system will be challenged if private standards (imposed, for example, by buyers or retailers) start to be barriers to trade. Currently there is no international mechanism to allow recourse against private standards, which is an emerging issue. In the framework of the value chain, ecolabelling demands and private standards for sustainability or quality or other technical standards by buyers or retailers that may indeed exceed public standards, intend to use consumer power or buyer power to force more responsible harvesting or production. This possible "substitution" or complementarity of buyer pressure for public regulation (if it is wanting) will have important implications for the trading system.

As noted, aquaculture is behind in not having yet established an international benchmark for aquaculture ecolabelling (guidelines) or in having a key recognized international ecolabel in place. There is a risk that retailers or buyers could choose an existing "branding" label as a "standard" or ecolabelling proxy and build buy-in to it, even if it might not fulfil all requirements of a full-fledged ecolabel as determined by states multilaterally. In this regard, current work underway within the FAO on an aquaculture ecolabelling guideline is an important step forward.

Especially important overall to the trading system affecting both capture and especially aquaculture fisheries will be an integrated traceability system that will integrate health and safety and sustainability needs.

Consumers

The responsibilities of market states affect all states. The expectations of markets will influence whether globalization causes a "race to the bottom" (low common denominator) or encourages a "race to the top" (higher common denominator) for safety, quality and sustainability. Markets that provide refuge for irresponsible product slow down global reform for sustainable fisheries and aquaculture. Markets should not undermine incentives for sustainability and safe products through low standards and/or poor consumer education

The largest markets for fisheries products are in Europe, the United States and Japan. As noted, developed states' markets are increasingly demanding on a range of fronts (quality, convenience, safety, sustainability). Buyers and consumers are demanding food safety (non-negotiable), freshness, diversity, convenience and increasingly, a focus on sustainability, legality and traceability. Some high-profile restaurateurs are a part of this demand, especially for value-added, reliable, uniform (and high quality) product. This puts pressure downward on the entire value chain, through processors (for higher value-added products) to producers who need to provide what is needed by processors and markets. It affects both capture fisheries and aquaculture products. As previously noted, aquaculture product may have a potential advantage in providing raw material for higher-value processed products to meet demands for higher quality and convenience.

The rising power of buyers, retailers and consumers in Europe and North America is one of the biggest market changes of recent years. Indeed, the OECD-FAO workshop learned of the determined efforts of major buyers and retailers to do what regulation and management may have failed to do up to now, by forcing, through buying power, increased harvesting/production responsibility, quality and sustainability. The view of these buyers and retailers was mixed, however, in relation to their obligations as part of the system of capacity building and facilitation, with some arguing that the issue is simple company branding and marketing (and explicitly arguing that their "business is not regulation, capacity building or development assistance"), with others building strategic and capacity-building relationships with suppliers all over the world to enable producers to meet their standards and thus create strategic supply links.

Commercial risk is again at the heart of this issue. Buyers, and through them, consumers, increasingly seek assurance of the quality and sustainability of the source of the products they are buying, and clear and accurate labelling on a range of issues. As far as sustainability is concerned, in addition to ensuring a steady supply source, retailers are demanding proof of sustainability also as a defence against ENGO threats or to create a market advantage of their "brand" among discerning consumers. The United Kingdom is at the forefront of this movement, especially because of more militant ENGOs, but the 2006 announcement by Wal-Mart, in the United States, of demands for Marine Stewardship Council (MSC)-ecolabeled fisheries product has been a major catalyst in this movement.

There is not yet much evidence that consumers are willing to pay more for such labels, however, except perhaps "organic", where prices do command a premium, and

which could be a niche for aquaculture that provides opportunities to prove sustainable practices and high quality. Organic certifiers also engage in capacity building.

More generally, the issue is "which standards? what proof?" Buyers, retailers and restaurateurs complained in the OECD-FAO workshop, and have also complained elsewhere, about proliferation of labels and standards on a large range of issues that is confusing everyone (including buyers) and which can be contradictory[7]. So some retailers are simplifying the terrain by unilaterally choosing ecolabels they will honour[8], and teaching their consumers to respect that as the appropriate standard.

For capture fisheries, the FAO ecolabelling guidelines (2005) help assure some fairness, transparency and rigour in ecolabelling, thereby serving the needs of both ecolabellers and producers. Even so, while guidelines were necessary, they are not sufficient to ensure a "level playing field" among fisheries, as examples exist of differential standards and application within even well known ecolabels such as the Marine Stewardship Council (MSC), where certifiers actually operationalize the MSC standard. Application and requirements can be quite variable, although recently the MSC has shown its desire to reduce this problem through additional codification of their standard to reduce certifier discretion.

However, as noted above, no such global ecolabelling guideline yet exists for aquaculture. The associated risk is that *de facto* standards will be set by retailers from whatever is currently available, and once a "brand" is built around this, it may be hard to adjust later to a different guideline should it be the case[9].

Meanwhile ENGO campaigns will be influential, as they are widely disseminated. Many are anti-aquaculture. This demonstrates the need for collaborative relationships and education and improved aquaculture reputation overall.

CONCLUSIONS

All of the above points to a similar conclusion: aquaculture has opportunities all across the value chain relative to capture fisheries, although higher up the chain, aquaculture and capture fisheries products tend to be complementary. Sustainable responsible production is the *sine quo non* at all stages:

- production: not to undermine own production potential (environment, reputation);
- processors: need security of supply, quality;
- investors and financial intermediation: unsustainability/poor practices are "bad bets";
- exporters: face standards (health and safety sustainability, labelling);
- retailers: to protect their market "brand" and ensure sustainable high-quality supply sources; and
- consumers: sustainability, ethic increasing, food safety.

Health and safety standards, whether perceived as "fair" or not, are said to be "non-negotiable" to many consumers and the states that have put them in place. So the real issue to improve benefits for globalization is to improve their application and enhance systems that will reduce transactions costs for those trying to meet them. Key issues are unpredictability in application, transparency, changeability, multiplicity and confusion,

[7] It should be noted in this respect that many ENGO "campaigns" focus on sustainability of product at a point in time, while ecolabels focus on the management system and could indeed be based on contracts for changes in practices in the future. Thus is it possible for ENGO campaigns and ecolabels to be conflicting as "indicators" of sustainability (e.g. achieve an ecolabel, but be on an ENGO "red" list).

[8] The Marine Stewardship Council (MSC) being the label of choice, mainly as it is the only full-fledged ecolabel currently in place, and has already surpassed over 600 MSC ecolabeled products across most continents.

[9] Nor is there a standard – or even common appreciation – of what is meant by "carbon miles", also an increasing commitment to sustainability. If not applied throughout the entire value chain for fair comparison across products and product source, they can become a misleading and "buy-local" barrier.

lack of capacity and organization to meet them. Harmonization, mutual recognition and capacity building are needed to improve the system.

We need to consider the global fisheries system, including aquaculture, as we do any other economic sector in a strong economy. It needs:

- a strong, stable and predictable regulatory framework;
- one that is enforced and fair; and
- one that includes corporate social responsibility.

This will ensure effective and responsible decision-making, and a flow of resources to their best value over the short and longer runs. Aquaculture is part of that framework, and inextricably linked to capture fisheries in many respects. Responsible producers, responsible markets and freer trade will help ensure benefits of globalization for aquaculture.

George Williams

Vice-President, Government & Environmental Affairs
Darden Restaurants, Inc.
United States of America

George Williams is currently Vice-president of Government & Environmental Affairs of Darden Restaurants, Inc., which owns and operates Red Lobster, Olive Garden, Bahama Breeze, Smokey Bones and Seasons52 restaurants. He is responsible for managing the sustainability efforts of the company, public policy matters, the Darden Restaurants Foundation and Community Affairs. He has been with Darden since 1972, when he joined the company as an attorney, after three years in private practice in Macon, Georgia. George is a graduate of Mercer Law School and attended Florida State University and the University of Georgia. Prior to law school, he served in the Peace Corps in Belize, Central America.

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Value-added seafood: opportunities and challenges – a United States restaurant chain perspective

George T. Williams
Vice-President, Government & Environmental Affairs
Darden Restaurants, Inc., United States of America

ABSTRACT

Darden Restaurants, Inc. is a Fortune 400 company listed on the New York Stock Exchange that owns and operates 1 450 casual dining restaurants in the United States and Canada. Company brands are Red Lobster, Olive Garden, Bahama Breeze, Smokey Bones and Seasons *52*. Red Lobster is a seafood restaurant chain, and seafood is also served by the other brands. Darden Restaurants has a long history of working with its seafood suppliers, both in the United States and foreign countries, to add value to the seafood products it serves in its restaurants. Among other benefits, value-added products enhance food quality, quality consistency and reduce kitchen preparation requirements. These benefits make it possible to offer guests an excellent dining experience at a good value. Darden Restaurants is committed to increasing the number of value-added seafood products and is seeking to purchase many of these items from suppliers in the country of origin. Efforts have been positive, but there have also been some challenges. The challenges to selling value-added seafood items can be summarized as follows: 1) creating an item that is appealing to our guests, 2) represents a value and 3) that is safe and meets all United States and Canadian governmental requirements. To better assist the reader in understanding what is required from a casual dining restaurant perspective, an elaboration of these themes is presented.

Thanks to the organizing committees for their leadership role in sponsoring this Global Trade Conference on Aquaculture, a subject of great importance to Darden Restaurants, the largest casual dining restaurant company in the United States. With our four distinctive brands – Seasons *52*, Olive Garden, Bahama Breeze and Red Lobster – we own and operate more than 1 400 restaurants in the United States and Canada – in which seafood plays a prominent role.

Underscoring the global nature of our purchases, we source both wild-caught and aquaculture seafood from more than 30 countries by direct purchases, a procurement practice that is unique in the United States restaurant industry. It is important to note that many of the aquaculture products we purchase have a valued-added component (i.e. headed, peeled and deveined shrimp or filleted, deboned and skinned finfish), and it is our desire to increase the number of value-added seafood items we purchase for reasons I will elaborate upon later.

Food safety and quality are essential ingredients to the success of our brands; and to ensure we fulfill those requirements, we have a Total Quality Assurance Department of more than 50 persons dedicated to this effort. Working from key locations in Orlando,

Florida; China; Thailand; India; Honduras and Ecuador, they inspect every facility that processes seafood for our restaurants.

Why is the sustainable growth of aquaculture seafood so important? For Darden Restaurants it is very simple – continued growth of demand for seafood in the United States and no growth in production from the wild capture fisheries. On the demand side, we have seen the *food away from home industry* grow from US$ 43 billion in 1970 to US$ 537 billion in 2007 – a growth trajectory similar to Darden Restaurants. This growth in locations that typically sell more seafood than is consumed at home offers a growing recognition that seafood is health food and population growth is a recipe for tight supplies. Our internal conservative calculations suggest that we will need an additional 400 000 tonnes (edible weight) of seafood by 2025 just to maintain current per capita consumption in the United States.

As mentioned earlier, we are also committed to increasing the number of value-added aquaculture products on our menus. We believe value-added aquaculture products provide us with a number of benefits, i.e. the restaurant manager can spend more time with our guests because he does not have to spend as much time in the kitchen preparing the meal, they deliver consistent freshness and quality that build customer loyalty, and creative and innovative menu items are often generated during the collaborative process between our brands and the supplier as they work to develop the value-added item.

While it is evident that value-added products return higher prices for suppliers, achieving success is not easy: it requires properly equipped production facilities and a careful and systematic approach to understanding what will appeal to the United States restaurant customer. We believe there are two essential components: in-depth knowledge of consumer food preferences in the United States plus the value-added item must represent a value to the purchaser. To illustrate the value point, a crab cake was developed for Red Lobster that met its taste and presentation requirements, but value was not consistent with the Darden business model, so it did not proceed beyond the development stage. Its rejection, however, did not deter the value-added suppliers, whose ultimate success generated about five million dollars in sales in its first year.

As you consider producing value-added products, it is critical that you ensure their safety and healthfulness. There are three non-negotiable requirements: 1) the item must not contain any ingredient that has the potential to harm a consumer; 2) it must meet all the laws, rules and regulations of the country where consumed; and 3) all ingredients must be traceable. Failure to adhere to these essential requirements can negatively impact the trust a consumer has in the brand that sells the value-added seafood item, thereby causing customer loss and other negative financial implications. For example, with the value of Darden's brands being as much as 50 percent of its market capitalization, a loss of trust in one of its brands caused by a real or perceived food safety issue has the potential for significant negative financial consequences. This is true – not only of Darden, but of any publicly traded company. That's why food safety must be, first and foremost, a priority when you sell value-added seafood products.

We know that real opportunities exist for aquaculture suppliers of value-added products. While producing them will have many positive outcomes for you and your business, it will require a dedicated effort, as it will not be easy.

Let me close by saying that at Darden Restaurants, we welcome the opportunity to work with you and hopefully one day have your value-added aquaculture products on our menus.

Andrew Mallison

Manager – Seafood Procurement
Marks & Spencer plc

Andrew Mallison graduated in Fishery Science and was first involved in aquaculture over 25 years ago, working for Unilever Research in early salmon vaccination trials with Marine Harvest, Scotland. After graduating, he worked in the Australian seafood processing industry for several years, before returning to the United Kingdom. Specializing in developing seafood producers in Southeast Asia, and North and South America, Andrew worked in industries as diverse as Alaskan wild salmon, Peruvian hake and prawn farming in Thailand. Over the last 25 years, he has worked in canning, freezing and chilled seafood, covering most major commercial species. He joined Marks and Spencer in 1996 to manage their procurement of seafood, a range of 25 species both wild and farmed from over 20 countries. Achievements include being recognized as the leading United Kingdom retailer for responsible fishing and farming by Greenpeace and the Marine Conservation Society (United Kingdom) in 2005, 2006 and 2007; and an international award from the Seafood Choices Alliance presented at the 2006 Boston Seafood Show. Andrew is a member of the Scottish Executive Ministerial Advisory Groups for Aquaculture and Sea Fisheries.

Aquaculture – what retailers expect from producers

Andrew Mallison
Manager – Seafood Procurement
Marks & Spencer plc

ABSTRACT

The United Kingdom's market is seeing an increasing trend towards ethically produced foods, consumers buying into foods that are made with respect for the environment, animal welfare and human rights. At the same time, the image of aquaculture has been damaged by reports of antibiotic misuse, cruelty to farm animals and the presence of dangerous contaminants in farmed fish. Producers need to understand the needs of the final consumer and make choices about their farming methods, electing either for the low-cost commodity model or also offering higher-value products aimed at the ethical consumer. Producers should understand that the modern consumer is aware and increasingly better informed of how farm animals and fish are raised and will make purchase choices based on ethical standards.

INTRODUCTION

I am going to cover what retailers, at least in the United Kingdom, expect from producers of farmed fish and hope to provoke some thought on alternative market niches and production strategies. You have already heard about certification schemes and ecolabels, so I am going to concentrate on the consumer.

To help you understand what shapes these expectations, our position in the market place and our customer, I am going to tell you a little bit about Marks and Spencer, then explore some of the trends in the United Kingdom's market. I am then going to cover how the United Kingdom's consumer has been turned off farmed fish and some of the negative attitudes we now have to overcome. Then the important bit on how producers can make choices that affect the consumer, the image of farmed fish and the future market potential of aquaculture products. Finally, our thoughts for the future.

MARKS AND SPENCER

Our business was founded over 120 years ago by Michael Marks, Russian refugee who, because he could speak no English, opened a market stall where a big sign said "Don't ask the price, everything is one penny". He then formed a partnership with Mr Spencer, a local businessman, opened shops and our company was born. Today, our turnover is around US$16 billion, we have over 500 stores in the United Kingdom, a further 220 stores worldwide in 35 countries and employ 65 000 people (Box 1).

Our business covers three main areas: things you can eat, things you can wear and then there is everything else. We are a specialist food retailer and would carry around 3 500 food products, only 10 percent of the number of lines found in one of the United Kingdom's supermarkets like Tesco or Wal-mart/Asda. We only sell our own label and only sell premium products.

Our share of the United Kingdom's food market is around 4.5 percent, but we have a strong seafood business – in areas like fish delicatessen, we trade at around 20 percent share.

Principles

Our business has really been built on five main pillars:

- We are usually a "top up" shop, with customers completing a main weekly shopping trip at one of the supermarkets, then coming to us for the treats, the food for dinner parties or special occasions, or where they just need to know the food is the best available.
- Our quality must be better and different from that of our competitors, or few customers would bother making the extra journey to one of our stores.
- While we charge a premium for our foods, we believe it is still good value, as value is price multiplied by quality.
- Like any business, we must provide a good service to customers, creating products that are convenient, easy to use and offered when and where customers want them.
- We must innovate and provide new ideas and finally, but very important to this morning's discussion, our customers must trust us to meet their expectations.

It is this aspect of our business that made our sales increase when the rest of the United Kingdom's market suffered down turns after bovine spongiform encephalopathy (BSE) in beef, *Salmonella* in eggs and Avian Flu in poultry. The only time we have not seen this effect was in salmon during the polychlorinated biphenyl (PCB) and dioxin scare in early 2004; more on that later.

Trust in foods is becoming an increasingly important brand value but is also becoming increasingly threatened as the media expose bad practice in the food industry, usually driven by cost cutting and a lack of understanding of how the consumer will react to decisions made by the foods industry.

BOX 1

Marks & Spencer plc

- Founded in 1884
- Turnover ca. US$ 16 billion
- 500 stores in United Kingdom; further 220 stores in 35 countries
- 65 000 employees

Ratings

- Most sustainable United Kingdom seafood retailer – Greenpeace 2005, 2006
- Most sustainable United Kingdom seafood retailer – Marine Conservation Society 2006, 2007
- Leading retailer Dow Jones Sustainability Index, 2003–2006
- Leading retailer for animal welfare – United Kingdom Royal Society for the Prevention of Cruelty to Animals, 2006
- Seafood Choices Alliance Global Seafood Champion 2006

Ratings

We think we are on the right track to reassure our customers that we are taking care of the food we sell. Several independent surveys have rated us as the most sustainable seafood retailer in the United Kingdom, and last year the Seafood Choices Alliance honoured us with their global Seafood Champion award for our work in sustainable sourcing (Box 1).

These surveys show how high profile responsible sourcing has become and has driven real change in the retail sector. No one wants to come last.

In case you were thinking this is all very nice but is it profitable as well? – yes, it is. In our preliminary results for the last financial year, profits before tax and earnings per share were up by nearly 30 percent, and we have no doubt that part of this is due to our fulfilling the consumer's need for reassurance.

Trend for Ethical Products

We not only believe our principles are right for our customer but also for the market as

a whole. The United Kingdom is often seen as the trendsetter for other markets, and whether this is right or wrong, producers should be aware of developments in the United Kingdom and be able to take advantage of them should market opportunities arise.

We have seen the trend towards convenient foods as we become time poor and cash rich, towards more prepared foods as we forget how to cook at home, and the change in shopping habits from the big weekly "fill the car at the supermarket" to smaller more frequent purchases, often on the way home from work, to grab something to eat for that evening.

One of the clearest trends however, is for ethical products, and I am just going to go through some of the indicators that convince us we must recognize that consumers are becoming increasingly concerned about how their food is produced.

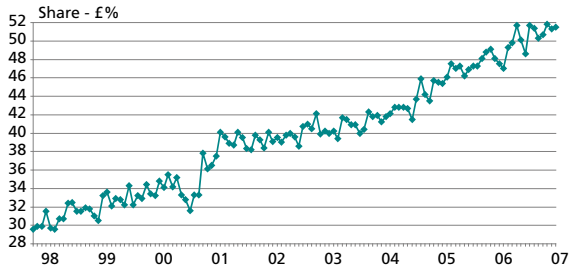
Hen eggs – free range share trends

The graph presented in Figure 1 shows how, over the last nine years, free-range eggs have increased from only 30 percent of the market to over 50 percent. For those not familiar with the idea of free range, the hens are allowed out of the sheds to range freely during daylight hours.

The eggs cost more but look the same as non-free range, probably taste almost the same –so why this increase in market share?

Photographs of hens raised in metal cages, standing on metal mesh, often with faeces from birds above dropping onto those below have been well publicized in the United Kingdom. Feathers are missing and the animal-loving British consumer can't help but find the system of keeping hens, also known as "battery farming", repulsive. On the other hand, photos of healthy hens with fresh grass underfoot, fresh air to breathe and sunshine to enjoy instinctively makes you feel that eggs from these hens are not only going to taste better, but by paying a few pennies more, you are helping the hens have a better life.

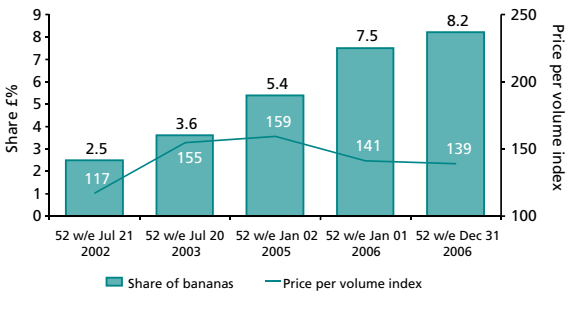
FIGURE 1
Hens' eggs – "free range" share



Fairtrade bananas

I am sure many of you will have heard of Fairtrade, supporting small growers and giving a premium back to the producer. Again price is higher; eating quality may not be that much different but, as you can see, there has been a steady increase of market share, four times higher in 2006 compared to 2002. Now that price is becoming more affordable as volume increases, shown in the graph in Figure 2 as the green line, we expect this trend to accelerate as consumers want to help small farmers around the world.

FIGURE 2
Fairtrade bananas – performance analysis



Organic foods

One of our fastest growing sectors is organic foods, and this mirrors the trend in the overall United Kingdom's food market. Prices are higher but consumers are attracted by reduced use of chemicals, better animal welfare and more "natural" products. Our business has committed to tripling the amount of organic foods we sell over the next five years.

Ethical trading

As we have seen with the emergence of Fairtrade, consumers want to know that workers in developing countries are protected and not exploited. Major international brands have been badly damaged through media exposures of poor working conditions in the manufacture of their goods, risking injury to workers or allowing the employment of children. In 1998, the Government of the United Kingdom set up the Ethical Trading Initiative, where information could be shared and standards agreed, now representing around 200 billion dollars of trade.

Marks and Spencer are a member of the Ethical Trading Initiative and would not trade with any company that does not meet our global sourcing standards and could risk damaging our reputation.

CUSTOMER EXPECTATIONS

Some recent research published by the Seafood Choices Alliance in the United Kingdom had some interesting findings on how the awareness of sustainable, responsible sourcing of seafood had penetrated the market and industry. These findings show that the consumer values environmental impact second only to freshness and above price, that business has accepted the need for sustainable sourcing and, if marketed properly, the consumer is prepared to pay a premium for the products.

Customer expectations of M&S

Over the last few years, we have asked our customers what they expect of us. From 2004 to 2005, the expectation to act responsibly increased from 75 percent to 97 percent and has stayed there. Last year, 78 percent of our customers wanted more detailed information on where our products come from and the standards that we apply to our suppliers. It is very clear to us that the market expects responsibly produced goods, has expectations of retailers and we, in turn, must apply these standards to our suppliers.

Farmed fish at M&S

We sell a lot of farmed fish. Our single biggest species, at around double the second largest by volume, is farmed Atlantic salmon. We also sell a number of other species (e.g. rainbow trout, prawns, Atlantic halibut), and as we progress, more farmed products such as cod, barramundi and maybe tuna will follow.

The demand for seafood is outstripping the ability of wild stocks to supply, and rightly or wrongly, the shortfall is being made up by aquaculture. How we deliver this additional supply is the key message in this presentation. Let's just look at some of the information our customers receive in their daily lives.

What customers see

As I mentioned earlier, in 2004, the United Kingdom's salmon market was hit hard by widespread media reports of dioxins and dioxin-like PCBs in farmed product. The fact that the samples had been taken some two years earlier, before changes to European Union (EU) controls on fish oils in feedstuffs, was not mentioned; and millions of dollars worth of sales were lost as customers stopped buying salmon.

The Government of the United Kingdom referred the issue to an expert group, the Committee on Toxicity, who found that the benefits of eating oily fish far outweighed the potential risk from contaminants and supported the official advice to eat oily fish. However, the damage was done and it took the rest of 2004 for sales to recover.

In Asia, it is not salmon but farmed prawns that have developed over the last 20 years. As with any industry, there have been examples of how prawns should be farmed and how they should not. Groups like the World Wide Fund for Nature (WWF) and the Environmental Justice Foundation have raised concerns about environmental impact, and the industry has responded with Codes of Good Practice.

However, there are still mistakes being made. For a small farmer looking at an outbreak of disease and the loss of his investment, it must be tempting to continue to use illegal antibiotics to treat the crop, and we are still seeing detections of illegal medicines on testing of imports into the EU, further damaging consumer confidence.

As if antibiotics, toxins and ruined farmland were not enough, there are also reports of local people and the animals themselves being mistreated. Add the threat of genetic engineering to create supersized fish, and it all adds up to a scary story (Box 2).

BOX 2
What customer's see about aquaculture in the media

- toxins and contaminants
- environmental impact
- illegal antibiotics
- human rights abuses
- animal welfare abuses
- genetic modification

What customers think

It is not very surprising then that the industry had managed to give itself a real PR problem. In Box 3 you can see that, on the plus side, consumers would eat more farmed fish to save wild stocks and that 65 percent are still going to buy regardless of adverse reports; the downside is that 25 percent would buy less fish if they knew it was farmed.

BOX 3
What customers think

- 54 percent are concerned about fish farming
- 65 percent say it will not change their behaviour
- 12 percent say it makes them buy less fish
- 58 percent say they would be happy to eat farmed fish to protect wild stocks
- 26 percent say if they knew a product was farmed they would buy less

Source: Seafish Industry Authority (United Kingdom)

THE FUTURE FOR M&S

A quick recap. We have a customer who is increasingly concerned about ethical issues, a market place full of negative messages about fish farming and evidence of this resulting in a developing resistance to farmed products. So what are we doing about it?

We are responding to the ethical consumer by trying to tackle the major challenges of the twenty-first century. Over the next five years, we are spending around US$400 million on becoming carbon neutral, sending no waste to landfill, sourcing sustainable raw materials, being a fair partner in the way we buy and taking steps to improve the health of our customers and employees.

This means we are going to be tripling the amount of organic food we sell, and finding ways of reducing the distances traveled by our foods from producer to processor to store. We will be selling more Fairtrade products, and all of our wild fish supplies will be certified sustainable by independent schemes such as the Marine Stewardship Council.

THE FUTURE OF AQUACULTURE

We see farming developing into two main areas and, for producers, the question is which is right for your business. The commodity model is high volume, efficient and primarily cost driven. When opportunities come along to reduce cost, they are taken up but without considering what the reaction from the final consumer may be. The mad cow disease scare in the EU was the result of a decision to use cheap protein from sheep in the feed for cattle, a choice most consumers would find unnatural.

The other model is the niche model, where the product is designed for a particular market or customer, accepting that some aspects of how the fish is farmed may be more expensive, but that the final consumer is willing to pay for this standard. Also implicit in this model is a responsibility for understanding the consumers' expectations

BOX 4
Low-cost or high-value feeds?

Option 1 – cost model
- Cost-driven formulation
- GMOs
- Consumer-averse ingredients (chicken feather meal, pork blood meal).

Option 2 – value model
- Formulated for eating quality as well as growth
- No GMOs
- Consumer-friendly ingredients (close to wild)

BOX 5
M&S "shopping list

Basic requirements that must be delivered
- eating quality
- safe & legal
- value

How fish should be farmed and what we believe our consumer wants:
- respect for workers
- low environmental impact
- attention to animal welfare
- feed materials sustainability and ethically obtained
- No GMO feed ingredients

in the way the fish is grown, ensuring that everything is done as if the final consumer were seeing everything on the farm and at the feedmill.

These two models are not mutually exclusive, and a farmer may be able to segment his production, using some sites for niche, high-value and others for commodity crops. We saw how the United Kingdom's consumers are responding to better farming conditions for free range eggs; the same will happen when consumers look into farmed fish.

Intensive or extensive prawns

Intensively reared prawns now dominate the market, but will they start to lose market share to more extensive production as consumer awareness of farming methods grows?

Low-cost or high-value feeds?

One of the biggest costs in farming is feed, and again farmers need to choose where they are on the scale between the low-cost model (Box 4, Option 1), which is all about cost, and the value model (Option 2). Feed is becoming an increasingly important battleground as the drive for sustainable and ethically sourced ingredients meets the demand for lower costs.

As non-genetically modified (non-GM) soya becomes harder to source and therefore more expensive, will producers move to GM crops? Do farmers know which species go into the fish meal in their feed? Are they well managed or endangered? As a retailer in the full spotlight of the media, we are very clear that low-cost feeds made from GM soya, unknown sources of fish meal or some of the less natural proteins like chicken feathers is a false economy – all it takes is one media report to drive our customers away.

While alternative protein sources may be ethical and perform well, it is the consumer who must be convinced that the feed ingredients we choose are acceptable.

OUR SHOPPING LIST

My presentation was called "What retailers expect from producers". Well, I can't really speak for all retailers, and there are many different markets with different needs. However, for our business, here is what we want. (Box 5)

Aquaculture producers need to decide if the low-cost or high-value model is right for them. How fish is grown and fed is increasingly important to the consumer and the reputation of the retailers. The high-value model may cost more to produce but if that is what the consumer wants, let's deliver it.

To close, I will just leave you with one simple message.

THINK CONSUMER

Linda Chaves

National Marine Fisheries Service
National Oceanic and Atmospheric Administration
United States Department of Commerce

Linda Chaves has had a career with the National Marine Fisheries Service (NMFS) since the late 1970s, working in a number of areas, including development of underutilized resources from the west coast and Alaska, improving market access for United States. fisheries products throughout the world, representing the United States in fisheries trade negotiations and disputes, developing regulatory infrastructure and research proposals for aquaculture development, and overseeing programmes and projects dedicated to seafood and health issues. She has represented the United States in international meetings and fora to advance United States fisheries interests in the World Trade Organization (WTO) and other international fora, including OECD, Asia Pacific Economic Cooperation forum (APEC), and the FAO Subcommittees on Trade and Aquaculture. She was the Director of the national Office of Industry and Trade and the Office of Constituent Services at NMFS from 1993 through 2003, when she was named the National Aquaculture Coordinator. She was subsequently appointed to be the Senior Adviser on Seafood Industry Issues to the NMFS director in December 2004 and now works primarily on fisheries trade, aquaculture, and seafood and health issues.

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The new consumer: seafood and health benefits

Linda Chaves
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
United States Department of Commerce

ABSTRACT

Today's consumer is much more educated, health conscious, demanding and inquisitive about what he or she will eat than the consumer of recent years. Consumers have become very interested in the health benefits and risks of seafood consumption, as well as environmental, social, and sustainability issues surrounding how the food they eat is produced, and of course they want to make sure that their seafood is safe. During the past several years, there has been a growing tide of evidence confirming the health benefits of all seafood, farmed and wild, for people of all ages. As nutrition and medical professionals accept the role of seafood in the diet for reducing the risk of coronary heart disease, new and exciting research suggests that a seafood-rich diet also helps in neurological development of the foetus, infants and children. Other studies have emerged that link diets high in seafood to mental health, the absence of depression and other behavioural disorders, and lower risk for other disease mechanisms. This new evidence should be good news to producers of seafood, particularly aquaculture products. The industry has an opportunity to produce healthy, safe products for an increasingly demanding market. Because the entire life of the cultured species is under its control, the aquaculture industry has the advantage over wild producers to produce a product that meets a nutritional profile aimed at increasing the health of consumers and providing essential nutrients to people young and old.

Michael J. Phillips

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Dr Michael Phillips is R&D program manager and environment specialist for the intergovernmental organisation of the Network of Aquaculture Centres in Asia-Pacific (NACA). Dr Phillips received his PhD from the University of Stirling, UK, in 1982 and has been working with NACA in Asia since 1992. Major responsibilities include building the research and development programmes of NACA, involving development of partnerships among governments, industry, scientific institutions, regional and international organisations and donors involved in aquaculture, aquatic resources management and rural development; incorporating environmental sustainability and management into NACA's regional aquaculture development programme; assistance in development of NACA's human resources development programmes, preparation and management of national and regional aquaculture development project activities; and recent emphasis on development of "better management principles and practice" documents and certification for responsible aquaculture. Dr Phillips was a co-director of the Consortium Program on Shrimp Farming and the Environment, that received a World Bank "Green Award" during 2006.

Aquaculture production, certification and trade: challenges and opportunities for the small-scale farmer in Asia

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ABSTRACT

This paper focuses on small-scale farmers in Asia and the challenges and opportunities faced in participating in global market chains for products from aquaculture. The bulk of aquaculture production in many countries in Asia is from small-scale, family-owned operations, perhaps making up to 80 percent of the production. The small-scale aquaculture sector is important for rural development, employment and poverty reduction. Small-scale farms may be diffused through a local area district or highly concentrated around specific resource (e.g. water supply). The small-scale sector, while innovative and a highly important part of the region's aquaculture production, faces increasing constraints, particularly for export crops such as shrimp. These include changing costs and business structures, access to modern market chains, exposure to increased market risks, increasingly stringent standards for food and other requirements, and limited access to markets, technical and financial services and knowledge. The commercial/government servicing, while well developed in Asia, also tends to be less oriented towards the small-scale farmer. Increasing trends towards certification, traceability and quality assurance schemes also risk disadvantaging the sector unless positive actions are taken to involve small-scale farmers and develop focussed strategies to ensure their participation. No certification scheme as yet targets the small-scale sector, but there will be significant social and economic benefits if the sector can be effectively serviced to participate in modern market chains. Some examples of the way forward are provided, including development of small-scale farmer organizations, group certification and services oriented towards the small-scale sector and the business opportunities it represents. These are rather new approaches for aquaculture, but lessons could be learned from other sectors, including agriculture and Fair Trade certification schemes. Recommendations to governments and the business sector for ensuring the participation of the small-scale aquaculture farmer in certification schemes and modern market chains in Asia are included.

INTRODUCTION

This paper focuses on small-scale farmers in Asia and the challenges and opportunities faced in participating in global market chains for products from aquaculture. The purpose of focusing on small-scale farmers is to raise attention to this large and important part of the aquaculture sector and the influence of production and market changes on the livelihoods of the many people involved.

Statistics on the small-scale aquaculture sector are poor, but it is important for rural development, employment and poverty reduction. The bulk of aquaculture production in many countries in Asia is from small-scale, family-owned and operated operations, perhaps making up to 80 percent of the farming community in some countries. Small-scale farms may be diffused through a local area district or highly concentrated around a specific resource (e.g. water supply). The sector, while innovative and a highly important part of the region's aquaculture production, faces increasing constraints, particularly for export crops such as shrimp.

Aquaculture is under transformation. It is not only growing in response to the huge demand for global seafood products and stagnation in capture fisheries, but especially for higher-value internationally traded export species such as shrimp. There is a trend towards a more integrated production-distribution chain with more focus on coordination between the aquaculture farmers, the processors and the retailers and to some extent the consumers and restaurants. It is no longer adequate for the farmers and organizations helping farmers to focus only on increased production; but it is now also important to understand how to link farmers to the production chain, how to produce high-quality and safe products, and how to have on-farm management practices that are highly efficient, taking account of the surrounding environment and social issues related to production. A further factor is the trend towards traceability, certification and improved farm management that is driving costs and responsibilities down the market chain to the farmer.

These global trends require changes in management for both large and small-scale farms to stay competitive. Whereas some larger farms with large product volumes and access to finance usually have the capacity to adapt and benefit from such trends, there are still many uncertainties related to the influence of such trends on small-scale aquaculture producers and their adaptation and participation in modern aquaculture production and market chains.

CERTIFICATION IN AQUACULTURE

Certification is rapidly being introduced to aquaculture, including mandatory and voluntary schemes. There are already a number of voluntary schemes emerging, and the number of certification programmes and labels for aquaculture products is expanding. Development and implementation of certification schemes is considered as one tool to help towards a more sustainable aquaculture production and at the same time link and inform different stakeholders in the production chain (Anon 2007).

At the same time, the trend towards certification risks disadvantaging small-scale aquaculture farmers unless positive actions are taken to involve small-scale farmers and develop focused strategies to ensure their participation. Surprisingly, no certification scheme as yet targets the small-scale sector, but there could be significant social and economic benefits if the small-scale sector can be effectively serviced to participate in modern market chains. Some of the constraints that the small-scale aquaculture sector faces related to certification include:

- small volumes of product from individual farms and large numbers of farms;
- low or no market incentives as yet to become involved in certification;
- complex marketing channels making traceability difficult;
- limited access to market, technical and business knowledge and related infrastructure;

- limited or inequitable access to financial services for investment in changes that may be required for certification;
- lack of formal farm registration and producers groups;
- inadequate traders-credit relations;
- lack of an export product, with farmers producing to least cost to sell within a less wealthy domestic market;
- commercial/government servicing less oriented towards the small-scale farmer;
- risk management strategies of larger traders and buyers requiring large volumes of product working against small-scale farmers producing small quantities of product.

The above issues need to be addressed. It is a matter of great importance to the industry and to a large number of people who depend on aquaculture as their main livelihood to engage small-scale farmers in the development of certification schemes to ensure equitable participation. There is a need to better understand the process, standards, their applicability, and the opportunities and challenges for small-scale farmers to benefit from certification systems.

It is unlikely in the near future that many individual small-scale farms can be easily certified, but one way forward may be to promote group certification or certification of clusters of small-scale farmers, an approach that has been used successfully in other agriculture sectors (e.g. organic products) (IFOAM undated). The nature of small-scale farmers is that they only produce small quantities of product, making it difficult and inconvenient for larger buyers who prefer larger volumes. The need for solutions to allow small-scale farmers to participate in market chains requiring certified aquaculture products is therefore evident.

EXAMPLE FROM INDIA

As part of a technical collaboration between the Marine Products Export and Development Authority (MPEDA) and the Network of Aquaculture Centres in Asia-Pacific (NACA) on shrimp disease control and coastal management in India, a village demonstration programme was conducted from 2002 onwards. The objectives of the programme were to:

- reduce the risk of disease outbreaks and improve shrimp farm production;
- organize the farmers under "self help groups"/"aquaclubs" for sustainable production; and
- produce better quality shrimp in a socially acceptable, environmentally sound and economically viable manner.

The programme was successful in improving organization of the small-scale sector and reduced risks, with nearly 800 shrimp farmers now participating across all of India's shrimp aquaculture producing states. Key elements of success include:

- the development of locally appropriate "better management practices" (BMPs) formulated with farmers, based on a science-based epidemiological study of shrimp disease risks and the International Principles for Responsible Shrimp Farming (MPEDA/NACA 2003, FAO/NACA/UNEP/WB/WWF 2006); and
- support to formation of farmer clubs (so-called "aquaclubs") within villages and within "clusters" of farmers. Clusters were defined as a group of interdependent shrimp ponds, often situated in a specified geographical locality and dependent on the same water source.

One of the most significant outcomes of this project is the reduction in disease prevalence and improved farm profitability as a result of BMP implementation in aquaclub farms. Successful implementation of BMPs reduced disease prevalence and increased the number of planned (normal) harvests leading to better crop outcomes, improved efficiency in use of key inputs (feed, seed) and profits. Another key to success was the development of farmer clubs, leading to a number of key benefits including:

- regular information exchange/sharing of knowledge on BMPs among farmers within the group and increased awareness among farmers;
- cooperation in buying high-quality farm inputs (seed, feed, lime etc.) at competitive price;
- increased interaction between farmers and input suppliers/farmed product buyers;
- stronger bargaining power of clubs in the purchase of farm inputs and sale of harvest, in the former case leading to reduced prices for bulk purchase;
- increased cooperation in sharing common facilities and in area improvements such as deepening of water inlets and unclogging of water supply/drainage canals;
- collective approach to dealing with common problems, including local environmental protection, especially protection of common water sources; and
- facilitation of farm licensing and formal registration of clubs with government. The formal registration has also recently opened opportunities for group members to access financial support from local banks.

Although the farmers are not yet formally certified, a farmer club and cluster management system in place provides a basis for moving forward towards voluntary certification.

WAYS FORWARD

The small-scale sector is the largest producer and the "mainstay" of Asian aquaculture. It is an innovative sector but faced with many problems and constraints in the modern trade and market environment. The sector is socially and economically important and cannot be ignored. Fortunately, recent experiences show that there are ways to assist small-scale farmer participation in modern market chains and trade.

One important way is the organization of farmers into producer groups. Examples from India and elsewhere show organized farmers can speak with a louder voice in negotiating prices for inputs such as feed and seed and potentially also have a better platform for more organized marketing and price negotiation when selling the product. A farmer group also allows buyers and extension facilities to have a focal point and hence reach a larger number of farmers with reduced costs. The way forward then is for public and private-sector investments to assist the small-scale sector to adapt and participate in modern market chains for aquaculture products. The public investments needed include:

- development of policy that is more favorable to the small-scale sector and at the very least, based on the requirements and realities of the small-scale aquaculture farmer;
- technical and marketing services that are more oriented towards small-scale aquaculture producers, as well as the small-scale traders and businesses associated with the sector;
- facilitating access to financial and insurance services in rural aquaculture farming areas;
- market access arrangements that support small-scale producers;
- information services that cater to the needs of rural farmers;
- encouraging private investment in small-scale aquaculture production and services;
- social "safety nets" for the most vulnerable producers and traders; and
- orientation of educational and research institutions towards supporting the small-scale aquaculture sector.

Trade rules and guidelines, including certification guidelines, also need to consider carefully the needs and realities of the small-scale sector.

There are many opportunities for private investment to support millions of small-scale farmers. Private-sector investments are needed in:

- technical and marketing services for small-scale aquaculture producers;
- information services;
- microfinance and financial services;
- insurance services; and
- input packaging and delivery for small-scale farmers.

We also consider that there is a business case for investment in the small-scale sector. In India, for example, an investment of US$ 80 000 in technical servicing in 2006 led to crop improvements worth US$ 2 million. Given that 70 to 80 percent of producers in Asia are small-scale, an investment in servicing the small-scale sector could therefore be a potentially profitable one.

"Corporate social responsibility" (CSR) also has a role to play in private-sector involvement in small-scale farming, particularly the larger retailers and trading businesses that are becoming increasingly powerful. These larger businesses should be encouraged to adopt more CSR initiatives in the aquaculture sector, such as

- facilitating market access for small-scale aquaculture producers;
- providing technical and financial assistance to small-scale producers to comply with market requirements; and
- developing brands and marketing favorable to aquaculture products from smaller producers.

Certification and quality assurance schemes are also needed that are relevant and practical for small-scale aquaculture producers. A focus on the advantages from small-scale producers should also be possible with regard to both environmental and social issues related to the production. Development of a small-scale certification scheme oriented towards "Fair Trade" as applied to some agriculture products should also be explored.

While many challenges clearly remain, with many questions, it is time to recognize the crucial role of small-scale aquaculture farmers in Asian aquaculture production and trade. The small-scale sector is the largest producer and the "mainstay" of Asian aquaculture. It is an innovative sector but faced with many problems and constraints in the modern trade and market environment. It needs investment from both public and private sector to compete and thrive in the modern aquaculture scene. There are many opportunities for assistance and investment. Ideas and partnership are certainly welcome!

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Bjørn Myrseth has worked with salmon farming since 1971 and has been involved with starting fish farming companies in Norway, the United Kingdom, Canada and the United States, as Managing Director of Sea Farms AS. This company was listed on the Oslo Stock Exchange as the first fish farming in 1985. From 1987, he has been Managing Director and one of the owners of Marine Farms ASA. This company started farming of salmon in Chile and the United Kingdom in 1987 and of seabass and seabream in Greece the same year. Today Marine Farms ASA has operations in the United Kingdom (salmon), Spain (seabass and seabream), Belize (cobia) and Viet Nam (cobia). In October 2006, Marine Farms ASA was listed on the Oslo Stock Exchange. The Company has about 300 employees and a turnover of about US$110 million. Bjørn Myrseth has given presentations at many international meetings on topics related to aquaculture. He has been President of European Aquaculture Society from 1992–1993. He received as Master's Degree in Fishery Biology from the University of Bergen in 1971.

New aquaculture candidates

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ABSTRACT

Global aquaculture is growing at a breathtaking speed. The quantities produced every year are not only increasing, the range of species farmed is also broadening. Some of them will probably remain niche products in the foreseeable future but others have the potential to conquer the world market. The time it takes from the development of efficient farming technology to large-scale production of a fish species is constantly decreasing. The success story of *Pangasius* proves that – provided the quality and the price are right – it often takes only a few years for a "new" fish species to capture the world market. While most fishes are currently still produced in the freshwater segment, it seems that the future will soon belong to marine species. This article presents several species that are considered to be particularly promising candidates for aquaculture. A lot of them are already produced in aquaculture but have still not made the definitive breakthrough – some of them for technological reasons, others due to economic considerations. At present, there are two fish species that are considered to stand a particularly good chance of market success: Atlantic cod (*Gadus morhua*) and cobia (*Rachycentron canadum*).

INTRODUCTION

All over the world new fish and seafood species are being sought that could be suitable for production in aquaculture. Two issues play a particularly important role in the selection process: has the technological side of farming been mastered, particularly reproduction, and is it possible to farm the species at a reasonable cost? The question of cost is of great significance for all species that have to face competition on the market from similar products from capture fisheries. While aquaculture producers have to pay for fry, feed etc. and also bear the risks involved in farming, fishermen can harvest what nature offers them at considerably less expense.

SEABREAM (FAMILY SPARIDAE)

One of the most interesting families for aquaculture is seabream (Sparidae). Apart from gilt-head seabream (*Sparus aurata*) of which 110 705 tonnes were produced in 2005, particularly in the Mediterranean region, other species are also produced worldwide. Total production of Sparidae in 2005 was 245 217 tonnes. Japan produced 76 082 tonnes of *Pagrus auratus*, and China 44 222 tonnes of unspecified Sparidae species. Beyond that, of the nearly 110 species in this family, other species that are regularly or occasionally produced in various quantities include:

- *Sparus hasta;*

- *Diplodus puntazzo;*
- *Dentex dentex;*
- *Pagellus erythrinus;*
- *Acanthopagrus schlegelii;* and
- *Acanthopagrus latus*

During the past few years, Spain's aquaculture industry succeeded in developing farming technology for red seabream (*Pagellus bogaraveo*). Although this fish species is susceptible to stress and the survival rate of the eggs and larvae is currently only 5 percent (industry standard for gilt-head bream is over 30 percent), there is sufficient stocking material available to ensure industrial production on a small scale. Spain registered an annual production of 118 tonnes in 2005, and production is expected to reach 300 tonnes in 2007. At present, the industry is trying to close the farming cycle completely and to build up a spawning stock from farmed fish. Because the fish are not ready for spawning until they are six or seven years old, this will take some time. The fry are transferred to net cages in the sea at a weight of 10 g. Red seabream grows slowly, so it takes about 36 months for them to reach 700 to 1 000 g (mortality is 10 percent at this time).

BARRAMUNDI (*LATES CALCARIFER*)

Barramundi, also called Asian seabass, has really already long lost its status as a candidate for aquaculture, for it is in the meantime farmed in considerable quantities in some Asian countries. In 2005, 30 970 tonnes were produced worldwide, over 90 percent of them in four main producers: Thailand (13 900 tonnes), Taiwan Province of China (7 862 tonnes), Malaysia (4 191 tonnes) and Indonesia (2 935 tonnes). In spite of this, it is still probably not wrong to call barramundi one of the "rising stars" of aquaculture, for in other regions of the world farmers only began taking an interest in this fish species during the past few years. Viet Nam and China have purchased fry to build up their own stocks. A barramundi farm has gone into operation in Massachusetts in the United States and in India, too, the species is considered a promising candidate for coastal mariculture. Already in the year 2000 a hatchery was opened in the Sirkazhi (Tamil Nadu) District.

Australian barramundi production rose more than a hundredfold from 15 tonnes in 1990 to 1 763 tonnes in 2003. One of the advantages of this diadromous migratory fish species is its salinity tolerance, which makes it possible to farm it in fresh, brackish or seawater. Barramundi grow quickly, particularly during their first year. It takes only 18 months from the fry to a 3-kg fish. Fish of this size are used for fillet production, while those weighing 400 to 600 g are used for portion fish.

The bottleneck in barramundi farming is fry production. Normally the fish lay eggs five to six times a year. Efforts are being made to optimize production of larvae and to eliminate *Artemia* from the farming process. Some hatcheries have already succeeded in at least partially replacing live feed with formulated feed. Fish that are raised on dry feed are even said to grow more quickly and uniformly. It is important that the fry are the same size to prevent cannibalism.

GROUPER (FAMILY SERRANIDAE)

About half of the 450 known members of the family Serranidae are traded under the unspecific name of "grouper". Due to high pressure from fisheries, 70 percent of grouper stocks are in the meantime considered to be overfished. Groupers are particularly susceptible to overfishing; they grow relatively slowly, can live to a considerable age and do not reach maturity until late in life.

It would thus seem very reasonable to farm groupers in aquaculture. About 15 grouper species are farmed regularly throughout the world. Most of these species belong to the genus *Epinephelus*, and it is mainly the two species *Epinephelus coioides* and *E. malabaricus* that are farmed. Other important groupers from aquaculture are:

- *E. amblycephalus;*
- *E. fuscoguttatus;*
- *E. lanceolatus;*
- *E. sexfasciatus;*
- *E. trimaculatus;*
- *E. quoyanus;* and
- *E. bruneus.*

Developments in grouper aquaculture (*Epinephelus* species) have been dynamic. A total of 9 410 tonnes was produced worldwide in the year 2000. By 2005, production had already risen to 65 055 tonnes. China and Taiwan POC are mainly behind this growth. China, which appeared in the FAO statistics for the first time in 2003 with a production of 26 790 tonnes, was already the biggest grouper producer in the world in 2005 with 38 915 tonnes. Despite high growth rates, however, aquaculture has so far only played a subordinate role in market supply. It is estimated that 15 to 20 percent of the groupers consumed worldwide come from aquaculture.

The biggest problem in grouper farming is obtaining fry. Although some species can already be hatched, most of the fry used for farming are caught in their natural environment (capture-based aquaculture). It is estimated that every year about 60 million juvenile grouper are caught to stock farms (for comparison, the total number of fry originating from hatcheries throughout the world is less than one million).

In spite of some success in more recent times, hatching groupers still poses a problem. Nearly all grouper species undergo sexual change. Usually the fish are initially female and do not become male until a later age. Spawning is governed by several interior and exterior factors simultaneously (e.g. hormone level, tides, temperature, moon phases) that are not easy to simulate under farm conditions. Feeding the larvae is also a problem. Reproduction is furthest developed in Taiwan POC, where two-thirds of the groupers in aquaculture are said to come from artificial reproduction. Taiwanese farmers apparently bring forward the fishes' sexual transformation by injecting hormones and thereby increase the share of male fish in the stock. There are ten big hatcheries in the country that hatch 15 grouper species more or less regularly, particularly *Epinephelus coioides*, *E. malabaricus*, *E. lanceolatus* and *E. fuscoguttatus*, to supply the country's approximately 600 grow-out farms.

SABLEFISH (*ANOPLOPOMA FIMBRIA*)

Sablefish, also called black cod, is one of the most valuable commercial fish species in the North Pacific. Its white, fat-rich, tender flesh is part of the standard range at sushi and sashimi restaurants. The most important market for sablefish is Japan. Due to its high market value, this fish would be excellently suited to aquaculture. Although there have been several attempts to farm sablefish, all of the projects failed so far due to financial or biological problems. Another farming project began in British Columbia (BC), in western Canada in 2003 with the establishment of a commercial hatchery. The company hopes to build up its own spawning stock from wild catches and then perfect reproduction and hatching technology.

As is often the case when farming marine fish species, feeding the larvae is a big problem in sablefish farming too. Hatching success fluctuates strongly from batch to batch, and there are occasional setbacks. Backbone deformations are frequent in the fry. Such defects are hardly detrimental to survival but the fishes are not very attractive and thus difficult to market. The investors who are behind the sablefish hatchery have also set up a grow-out farm with 12-m net cages on the Sunshine Coast (BC). Within two years, the fish there will have reached a marketable size of 2.5 to 3 kg. The main buyer is Japan.

POMPANO (*TRACHINOTUS* SPP.)

Some species of the genus *Trachinotus* (family Carangidae) are particularly popular in certain parts of the world. Capture fisheries fluctuate strongly from year to year, with a downward tendency. In 1983 the catch still amounted to 55 234 tonnes; in 2005 it was only 4 525 tonnes.

Due to the constantly good demand for these fish, pompano species are promising aquaculture candidates with good market predictions. Hatching and farming technology are still at an early stage, however, and production volume fluctuates very strongly. Some 330 tonnes were farmed worldwide in the early 1990s, but in 2005 production was only 55 tonnes (34 tonnes from Singapore, 18 tonnes from Hong Kong, SAR). An American company is currently making a new start with producing *Trachinotus carolinus,* which is one of the most expensive fish species on the United States market.

CROAKER (*ARGYROSOMUS* SPP.)

In several European countries interest has grown in farming croaker, also called meagre or corbina. Aquaculture production is currently only 800 tonnes but has displayed considerable growth over the past few years. A total of 33 tonnes was produced in 2000; 800 tonnes in 2005. The main producer is Spain with 347 tonnes, followed by France with 267 tonnes and Italy with 186 tonnes. The species already grows very well at temperatures of 16–20 °C, and it has a high market value, particularly the larger fish weighing over 2 kg.

A further species of this fish, Japanese meagre (*A. japonicus*), is farmed in southern Australia. The main buyer for this species is the United States. This white fish is considered an inexpensive substitute for Chilean sea bass (*Dissostichus eleginoides*).

ATLANTIC HALIBUT (*HIPPOGLOSSUS HIPPOGLOSSUS*)

Despite good progress Atlantic halibut is not farmed on a large scale and probably never will be. The high production costs and market prices paid for this fish species make farmed halibut a niche product. Experts believe that total production, which amounted to 1 445 tonnes in 2005, could stabilize at around 3 000 to 5 000 tonnes during the coming years.

The market for Atlantic halibut is probably viewed too optimistically in many forecasts, however. In Europe, the species can only be sold in larger quantities in Norway, Sweden and Great Britain. North America would be a lucrative market were it not for the competition from Pacific halibut (*H. stenolepis*), of which more than 40 000 tonnes are still caught per year in the Pacific.

Halibut farming is complicated and costly. It takes about five years to farm the fish to a marketable size of 5 to 7 kg. The biggest problem is supply of fry in sufficient quantity and good quality. Usually the fry are kept in on-shore tanks until they reach a weight of 1 to 1.5 kg before they are put into cages in the sea. This lengthy phase in land-based tanks pushes the production costs up. Although the price for fry fell from €7 to 3.60 to €2.50 per fish, it is still relatively high. In spite of attractive market prices, there are only a few companies that make profits with halibut farming; and if market supply continues to rise, prices might even fall.

TUNA

Capture fisheries of the most important tuna species (albacore, yellowfin, skipjack, bigeye, bluefin) rose from 3.84 million tonnes in 2000 to 4.25 million tonnes to in 2005. This rise was mainly the result of higher catches of skipjack (over 50 percent) and yellowfin (30.5 percent). The high-quality bluefin species that are particularly popular on the sushi and sashimi market account for only 0.9 percent of the total catch. This gap is a chance for aquaculture. Tuna farms have been set up in several different regions around the world within just a few years. It can at present only be guessed just

how much is produced there. FAO figures name a total production in 2005 of 22 995 tonnes. According to the tuna farming industry's own figures, however, they already produced approximately 32 500 tonnes in 2004. The main tuna-farming regions are the Mediterranean (Spain, Croatia, Cypress, Italy, Tunisia), Central America (Mexico) and Australia.

Tuna farming is a typical form of capture-based aquaculture: young tuna are caught in the sea and put into net cages where they are grown to a marketable size. This technology was first used in 1985. To stock the huge net cages in the sea (which sometimes have a diameter of up to 100 m), young fishes are mostly caught at a weight of 15 to 45 kg. On average, the tuna are fed for three to six months in the sea cages, during which time their weight usually increases by a third. Inexpensive fish species such as herring, sardines, anchovies and sardinellas or mackerel serve as feed. Harvesting is usually carried out on order when the quality and size of the fish fits demand and the prices are right. The tuna produced in aquaculture are mainly species with a high market value:

- northern bluefin (*Thunnus thynnus thynnus, T. tonggol*);
- southern bluefin (*T. maccoyii*);
- bigeye (*T. obesus*);
- yellowfin (*T. albacares*); and
- albacore (*T. alalunga*).

In volume terms, bluefin species account for more than 90 percent of production. They get the highest prices on the market.

Although farmed tuna only accounts for 4 percent of the Japanese tuna market (450 000 –500 000 tonnes), it is of great significance because it is traded almost without exception in the high-price toro (belly of the fillet) segment. While the share of toro is only 30 percent in capture fisheries, it is practically 100 percent in the aquaculture sector. This led to oversupply of high-value species and to a considerable price drop on the sashimi market. Supply of bluefin, for example, rose by more than 50 percent (80 percent of growth came from aquaculture). The Japanese sashimi market is now divided in two, with a high-price segment for wild tuna from capture fisheries, which gets top prices, and a mass market for farmed tuna, which offers sashimi at affordable prices. Because the Japanese market, which up to now bought nearly all of farmed production, now seems to be largely saturated, the further development of tuna farming will partly depend on whether new target markets can be developed. The industry currently harbours great hopes in the United States, whose demand for premium tuna (sushi, sashimi, barbecue) is about 45 000 tonnes per year.

There are still some unsolved problems in the tuna-farming sector: routine reproduction of fish to replace capture-based aquaculture and the development of a dry feed that could be used as the sole feed. Although there has been some progress in both areas, the industry is still a long way off a real breakthrough.

Environmental organizations are critical of tuna farming. The World Wide Fund for Nature (WWF) demands a moratorium for Mediterranean fish farms. In their opinion, farming endangers the overfished tuna stocks because there are no regulations, supervision or control of catches for stocking the farm cages.

YELLOWTAILS (*SERIOLA* SPP.)

Yellowtails have long been produced in aquaculture in Japan. During recent years other countries have also entered this field of aquaculture. Although it is possible to raise some species from the egg, stocking material is still mostly caught in the wild. In 2005, 172 594 tonnes of yellowtail were produced worldwide, 159 741 tonnes by Japan. Nearly all of the Japanese farms produce *Seriola quinqueradiata*. In other regions of the world, two other *Seriola* species are farmed: yellowtail kingfish (*S. lalandi*) and amberjack (*S. dumerili*).

TABLE 1
Characteristic features of the three *Seriola* species

	S. dumerili	*S. quinqueradiata*	*S. lalandi*
Common name	Amberjack	Yellowtail	Goldstriped amberjack, yellowtail kingfish
Max. length	180–190 cm	150 cm	250 cm
Max. weight	80 kg	40 kg	97 kg
Distribution	Circumglobal, subtropical waters	North West Pacific, subtropical waters	Circumglobal, subtropical waters
Market size	3.5–5.5 kg for sashimi	Up to 6 kg for fillets, 3.5–4.5 kg for sashimi	Up to 4 kg for fillets and sashimi

All three *Seriola* species have white, tender flesh with a very pleasant taste. The meat of farmed yellowtails contains more fat than that of caught fish, and this is a particular quality feature in Asian countries. For this reason, yellowtails are among the few fish species for which demand for farmed fish is greater than for wild fish. The prices paid for farmed yellowtails are more than twice as high as those paid for their wild counterparts.

The bottleneck that is holding expansion of aquaculture back is obtaining fry for stocking. Japan has placed restrictions on the removal of juveniles to protect wild stocks, and only about 40 million juveniles can be caught per year. During the past few years, however, even this quantity was rarely exhausted and the catches often amounted to only 25–30 million fish. The farmers prefer fry weighing between 30 and 100 g. To catch the fish, fishermen make use of the juveniles' typical behaviour: they are often found beneath flotsam, and so the fishermen use fish aggregation devices (FADs), which are floating rafts made of plants or other materials. After the fish have gathered there, they can be caught using small purse seines, lift nets or hand nets.

Farming is mainly done in floating net cages, but occasionally in fenced-off sea bays. The farm location is largely decisive for its success, for yellowtails are demanding fish. A slight current, clean water and constantly high temperatures (the fish stop eating at temperatures of below 15 °C) are prerequisites for healthy fish and good growth. Regular sorting by size prevents cannibalism. If fed well, the fish grow quickly. Fish stocked at 50 g can reach weights of 200–700 g in three months. Weights of 600–1 600 g are possible after six months and 700–2 000 g one month later. The fish are fed with fresh or frozen fish: preferably sardinella, horse mackerel or mackerel. Feeding only sardines and anchovies is less suitable because their unsaturated fatty acids oxidize quickly and can cause vitamin B1 deficiency in yellowtails. The food conversion ratio (FCR) is usually between 5 and 7:1. In principle, pellet feed is also possible if the fishes have been conditioned to eat it. About half of all Japanese yellowfins are already farmed using special dry feed. The fish are mostly transported live for the sushi and sashimi market.

With regard to production volume, Japan is the world leader in yellowtail farming. The industry's profitability has decreased, however. The reasons for this are mainly to be found in rising production costs (feed) and lack of stable supplies of fry. Added to this is the fact that in the meantime other countries have also recognized the market potential of *Seriola* species, with the result that competition has become harsher. Today, *Seriola* species are also produced in Taiwan POC, Australia, New Zealand, Ecuador and Viet Nam. Spain has started test production on a small scale, and Italy, Croatia, Greece, Malta and France are also examining the possibility of farming the species. In contrast to Japan that has stuck to *S. quinqueradiata*, these countries mainly farm *S. dumerili* and *S. lalandi,* which have a higher market value. Some key features of *Seriola* spp. are given in Table l.

STURGEON (FAMILY ACIPENSERIDAE)

When wild sturgeon stocks were still in good condition and supplied enough caviar, there was not much interest in farming these fishes. However, the situation has changed

fundamentally in recent years because the natural stocks are strongly overfished and the quantity of wild caviar available on the world market has fallen drastically. Since 1997, trade with sturgeon and sturgeon products has been regulated by the Washington Convention on International Trade in Endangered Species (CITES). Twenty-three sturgeon species were put on the CITES Appendix List II and two species on List I. Since then, CITES permission has been necessary for trade with sturgeon and sturgeon products on the world market.

This decline in sturgeon fishing has led to new chances for aquaculture. The attractive market prices for caviar are awakening hopes that the difficult and expensive farming of these fishes might be profitable and lucrative in investors and farm operators all over. According to FAO statistics, 328 tonnes of sturgeon were produced in aquaculture in 1990. The figure named for 2005 was 19 648 tonnes. China is the biggest producer with over 15 000 tonnes. The following are the main sturgeon species currently produced in aquaculture:

- Siberian sturgeon (*Acipenser baeri*);
- white sturgeon (*A. transmontanus*);
- Adriatic sturgeon (*A. naccarii*);
- spoonbill (*Polyodon spathula*);
- sterlet (*A. ruthenus*);
- waxdick, Danube sturgeon (*A. gueldenstaedtii*); and
- bester (hybrid of beluga and sterlet).

SEA URCHINS

Sea urchin roe is one of the most expensive seafood delicatessen products in the world. In Japan, sea urchins are traded for between US$6 and 7 per piece depending on size and type, and people pay about US$340 per kg for the roe. Wild stocks of sea urchins that come into question are often under pressure, however, or are overexploited, so that aquaculture presents itself as an alternative.

The attempts made so far to farm sea urchins have not been very successful. In the past, for example, farmers tried to grow them in polyculture together with fish. The sea urchins would, it was hoped, feed on the algal growth on the nets. In practice, however, this source of feed proved to be insufficient, particularly since the algae were often covered by a layer of fish faeces. Apart from that, the net cages could no longer be cleaned by hand on account of the risk of injury through the sea urchins. In spite of these and similar drawbacks, interest has risen again in sea urchin farming during the past few years. A long-term study conducted in Australia revealed that sea urchin farming could be a million-dollar business.

In Norway, an automatic cage system was developed for sea urchin farming. It consists of a floating raft from which latticework boxes are hung into the water on ropes like the rungs of a rope ladder. The boxes are lifted automatically to the surface for feeding and control purposes. Due to the high level of automation, two operators are sufficient for managing a farming facility of 3 000 m^2. The system is also said to be suitable for other species, e.g. abalones.

Marketing sea urchin roe might prove a problem, however, for sales are almost solely limited to Japan, which absorbs 90 percent of world production. Concentration on just one buyer creates a strong dependency and would make this branch of aquaculture highly susceptible to disruptions.

ATLANTIC COD (*GADUS MORHUA*)

Atlantic cod are distributed throughout the northern Atlantic, the Baltic Sea and the Barents Sea. It is a very adaptable species with separate stocks inhabiting a wide range of environments. Cod stocks have declined and are now considered to be below safe biological levels in many areas. Over-exploitation of wild cod has led to a sharp

increase in the market value of cod and has stimulated great interest in the farming of this species. In response, research into cod farming has been carried out in several northern countries, in particular in Norway, Canada and the United Kingdom. Key elements needed for launching a profitable industry appear to be almost in place, but cod farming is still in an early start-up phase, Cod farming is a tricky business – far trickier than salmon. To reach profitability, farmers have had to overcome a number of obstacles, including cannibalization, premature sexual maturity and low survival rates that plagued early efforts.

Production methods and practices are rapidly being improved, and it is hoped that in the near future a year-round supply of premium-quality farmed cod will become available. In order to meet market demands, the aquaculture industry has focused on a step-by-step development. Much of the farmed cod that has been sold until now has been wild sea-ranched cod, caught as medium-sized fish during the spring fishing quota by small coastal fishing boats. These cod are held in ordinary net cages and are fed for 6 to 9 months until they are slaughtered in autumn-winter, when they weigh between 4 and 5 kg and quality is at a peak. Captive fattening up to commercial size was developed in Europe (Scotland, Norway and Iceland), in Canada and in the United States (Maine).

Cod rearing in captivity for sea-ranching has been carried out for over 100 years in both Norway and Canada. Until the 1970s, the objective was to produce fry to replenish local wild populations. Interest in "real" cod aquaculture based on fry that are hatched under controlled conditions was developed in the 1970s and 1980s. In 1977, cod were reared from eggs to mature fish for the first time in captive conditions. Farmed cod live in their own net cages that have been developed for cod farming, much like salmon farming. During a two to three year period, the fish reach a slaughter weight of between 3–4.5 kg.

Controlled cod production from broodstock to ready edible fish is an extensive process. The two-year farming cycle of cod is comparable to that of salmon. Wild cod become sexually mature at between 2 and 7 years old. Age of maturation varies between stocks and is linked to the growth rate of the fish. The cod matures – depending on the location – from January to March, yet the production of eggs and larvae can take place all year round. Fecundity is huge. It is not uncommon for a mature female to produce 250 eggs per g of body weight. Therefore, a captive female of 3.5 kg can lay between 3 and 5 million eggs. Cod eggs are small, typically 1.3–1.5 mm in diameter. Hatching starts after a period of 10 to 14 days at a temperature of 6–8 °C. When they hatch, the cod larvae are 3.5–4.5 mm in length and, compared to salmon, are relatively undeveloped. The larvae feed on their yolk sac for about a week, then on live planktonic prey, and later on artificial food (micro-particles). After approximately 35–40 days, the cod larvae undergo metamorphosis so that they become recognizable as fish.

For years the cod farming industry was hindered by a lack of juveniles. Even today the production of sufficient numbers of juveniles remains one of the biggest problems facing cod farmers. Up until now the preferred method to get fertilized eggs has been natural spawning. Males and females ready to spawn are placed together in land-based vats where the females spawn without human influence and the males fertilize each spawn the natural way. Sex and state of maturation can be determined quickly and easily with the use of an ultrasound scanner. The vats are stocked at densities of 5–10 kg/m^3 with a ratio of 1:1 to 1:3 females to males. Cod are termed "batch-spawners" because females do not release all of their eggs at one time. Mature females typically produce 15–20 batches of eggs at intervals of 60–75 h during a period of 40–60 days. During spawning season the quality of the eggs from any one female cod may decline.

The fertilized eggs float freely in the tanks and are collected from a sieve collector that stands in the water outlet of the vats. Then the eggs are disinfected and transferred to incubator tanks to be bred in darkness. The 6–8 °C cold seawater in use has been

filtered and sterilized with ultraviolet light. Under such conditions the tiny larvae hatch after two weeks. Two production methods are used to ensure survival of fry through the critical phase: one is in land-based tanks; the other is based on fry set out in small closed sea lakes or in plastic bags in shallow sea areas. Both methods produce good-quality fry.

Cod larvae are usually stocked at 50–100 animals/liter, although higher stocking densities are possible provided water quality is maintained at high levels and sufficient amounts of feed are given. Light should be given continuously throughout the larval stage. Algae are also added to the larval tanks. There are many reasons why algae are required and essential for successfully rearing cod larvae. Prey animals such as rotifers and *Artemia* are used as a food source. The timing of the introduction of each type of feed varies with the growth rate of the larvae. It is essential for the larvae to start feeding on these organisms before their yolk-sac reserves are used up (circa 6–8 days post-hatching), otherwise starvation and mass mortality will result. When the larvae have reached a certain stage of development, *Artemia* are introduced. Rotifers should continue to be fed for 5–7 days after the introduction of *Artemia* to allow the larvae sufficient time to adjust. Neither rotifers nor *Artemia* are nutritionally sufficient to sustain the cod larvae and they must therefore be "enriched" with commercially available supplements. The type and application of these enrichments can be crucial to the success of a hatchery.

Weaning onto formulated diets begins approximately 35–40 days post-hatch, while *Artemia* are still being fed. Recently it has become possible to wean earlier – a significant improvement since live feed production is very costly. Survival through to weaning is commonly only 5–25 percent, although this figure is improving with better practices. Survival rates are affected by outbreaks of bacterial diseases, notably vibriosis. Good hygiene helps to prevent these outbreaks. The major challenge during the nursery stage is preventing cannibalism. Cod are extremely cannibalistic between 2 and 4 months old. The effects of this can be very serious if left unchecked. Frequent grading using a floating bar grader and provision of sufficient qualities of feed contribute to overcoming this problem.

The on-growing stage of the cod production cycle is almost identical to that of salmon. Much of the necessary technology, equipment, infrastructure and experience are already in place. Juvenile cod are ready to be stocked into sea-based net cages if they are approximately 6–7 months old, completely weaned and have a weight of 30–100 g. Generally, farmed cod are easy to keep in farms and tamer than salmon. For instance, they swim towards visitors instead of fleeing away. As a demersal species, cod keeps itself low in net cages. Their optimal growth temperature is about 12 to 15 °C. Cod accept densities of up to 40 kg/m^3. The formulated feed is a special protein-rich mix in the form of dry pellets. The feed is primarily based on marine raw materials such as fishmeal and fish oil. Cod is a lean fish that stores fat in its liver, while the fillet has a high content of protein. Higher fat levels in feed result in enlarged livers that can have over 15 percent of the total body weight. This means a significant reduction in the edible yield of fish.

Cod cannot utilize high amounts of carbohydrate because this will lead to a diabetes-like state in fish and decrease utilization of fat and protein. On average, the protein content of feed is between 50 and 55 percent, but there is no protein from land animals. A part of the fishmeal can be replaced by good vegetable raw materials – mainly soy meal – without affecting meat quality and taste. The lipid content in the feed ranges from 12 to 18 percent. The fish oil used contains mainly anchoveta from South America because of its high omega-3 content. The feed pill also contains vitamins and a mineral mixture.

Growth performance is considered good with feed conversion ratios of 1:1. At present, many cod hatcheries are using wild-caught broodstock, although captive

reared fish are now becoming available. Breeding programmes can be developed with the aim of selecting better-performing fish. However, domestication of cod has been an expensive and time-consuming process for the aquaculture industry.

In 2002, Norway started a National Breeding Programme for cod close to Tromsö, both in a land-based facility and a floating net-cage farm. Two hundred cod families are included. Breeding is targeted on fast growth, disease resistance, better feed utilization and late maturation. For evaluation of individual performance, each offspring is tagged with a radio transponder before being released into the sea cages.

To become a commercial reality, a year-round supply of eggs and juveniles for cod farming is required. The short length of the spawning season is therefore a potential problem. Research has succeeded in producing eggs outside of the natural spawning season through manipulation of water temperature and day-length (photoperiod). In this way the spawning season can be extended or shifted. Because farmed cod experience high growth rates, they tend to mature earlier than wild fish. This may occur prior to reaching market-size, with a consequent loss of performance and condition. Experiments have shown that this may be prevented by using lights as is done in salmon farming to delay grilsing. However, in the case of cod this method has not yet been fully developed and must be perfected further.

In comparison to salmon, the cod farming industry still has only limited knowledge of fish health concerns. During the on-growing stage, cod are susceptible to a number of pathogens. Vibriosis has proved to be a problem, although vaccines have been developed in Norway and Canada. This is a definite advantage for farmed cod, both in terms of growth performance and more importantly, for sales and marketing. Extensive research is being done to prevent outbreaks of disease. However, development of effective vaccines requires much time. Important progress would be the development of special weaning diets to replace live rotifers and *Artemia*, which can be a critical risk point for introducing pathogenic bacteria.

The main challenge of cod farming seems to be vibriosis and bacterial furunculosis. Several outbreaks of classical vibriosis even in vaccinated cod were reported in recent years. Furunculosis was confirmed for the first time a few years ago in farmed cod in Norway. Since then, the disease has been reported in an increasing number of fish farms along the coast. Up to now, three different variants of the furunculosis bacterium have been registered in diseased cod. Furunculosis vaccine that has been developed for salmon does not provide satisfactory protection for cod. Fortunately, viral diseases are not yet a problem. Cod can also experience problems with sea lice (*Caligus* spp.), which can be treated in the same manner as for salmon. While wild cod are prone to infestations of tapeworms and roundworms, first experience with farmed cod shows a very low incidence or absence of these organisms.

The outlook for cod farming is excellent. Cod is a well-introduced species, and there is a large and established market for this species in Europe. The United Kingdom cod market alone has been estimated at 200 000 tonnes, of which 85 percent was imported from Iceland, Russia and elsewhere. The decline in wild catches has resulted in a long-term increase in prices. Production is growing, but more slowly than expected in previous years. The journal *Fish Farming International* wrote in 2003 that Norwegian cod production could reach 175 000 to 225 000 tonnes by the end of the decade and soar to 400 000 tonnes by 2015. Compared with this very optimistic forecast, reality can only be disappointing. In 2006, Norway just reached a total production of 7 000 tonnes – far behind the projections. But independent of this it is a sure thing that cod farming after salmon will be the second big wave of aquaculture in Norway.

This is on condition that prices of farmed cod remain strong. Cod farming can only be viable and feasible provided certain economic preconditions are met. However, there are at least two unpredictable risks. First, it is well known that the volume of production will have a direct effect on price. Due to protein-rich feed and high

juvenile production costs, cod farming is expensive. As long as the production volume is low, farmed cod can be marketed at premium prices in niche markets, but as volume increases prices will inevitably fall. The second unpredictable risk for cod farming is the state of wild cod stocks. If wild cod stocks recover it would definitely have an effect on market price. Markets could shift back from farmed to caught cod again.

Even under these circumstances cod farms can survive. Like many other species that come from aquaculture, farmed cod has remarkable advantages over its wild counterpart in terms of year-round supply, traceability and freshness that should ensure a good demand for this product.

COBIA (*RACHYCENTRON CANADUM*) (Bjorn Myrseth)

The cage culture of cobia started on the early 1990s in Taiwan Province of China, the first successful larviculture occurring in 1994 (Liao, Su and Chiang 2001).. Today, cobia is farmed in the United States (Puerto Rico), the Dominican Republic, Martinique, Panama, Mexico and Belize in the Caribbean. In Asia, farming is taking place in the People's Republic of China, Japan, Viet Nam and Thailand. Experiments have been carried out in Reunion in the Indian Ocean. In the United States, cobia is also farmed in recirculation aquaculture systems in Virginia. The estimated world production of cobia is given in Table 2. China is the biggest producer, with an annual production of 20 000 tonnes (Dr. Jiaxin Chen, personal communication).

Cobia requires warm water to do well, growing best between 25 °C and 30 °C. According to Chang *et al.* (1999), feeding stops at 19 °C and mortality occurs at 16 °C. and at 36 °C. Cobia is a euryhaline species, feeding well at a salinity of 4–35 ppt (Chang *et al.* 1999).

Cobia has all the domestication traits we would like to find in cultured fish. The life cycle is closed; the fish spawn naturally in tanks and hatchery production of larvae is well established. The growth is fast, and in tropical waters the fish reach a size of 5–6 kg in just one year after hatching (Figure 1). Cobia can be handled without being damaged and do well in cages at a stocking density of 10–15 kg/m^3. They grow well on "standard" marine diets with "low" fat content (15 percent fat). Craig, Swarz and McLean (2005) have shown that a large portion of the fishmeal can be substituted with soya protein without reducing growth. The feed conversion ratio (FCR) is generally low, being 1.4–2.0.

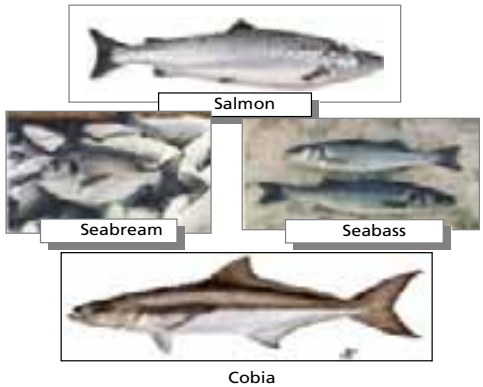
The flesh of cobia is white and firm, tolerates heat well and has excellent eating qualities. It can be boiled, broiled, grilled or deep-fried and is good when eaten raw as sushi and sashimi.

The short-term challenges to cobia culture include diseases and market developments. Both areas require more research and attention. In the long term, improvement of feeds

TABLE 2

Production costs, seabass/seabream, salmon and cobia

	Seabream / Seabass	Salmon Norway	Cobia China
Feed	2.00	1.24	1.87
Fry	1.05	0.31	0.17
Labour	0.94	0.22	0.31
Other	0.44	0.32	0.19
Depr.		0.14	0.43
Total	4.43	2.23	2.97
Finance	0.81	0.09	
Ex cage cost	5.24	2.32	



Target USD 2 / kg for cobia

FIGURE 1
Comparison of growth of cobia with that of some other cultured species

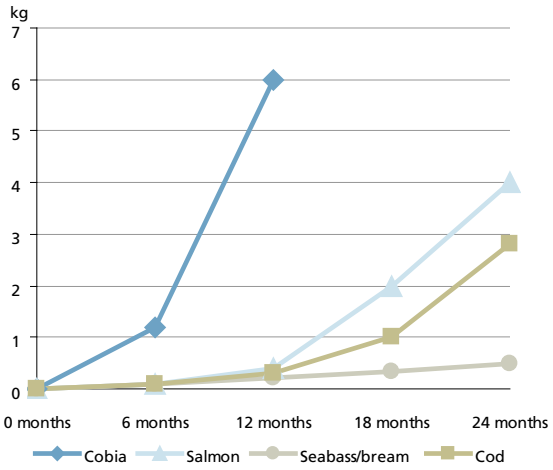
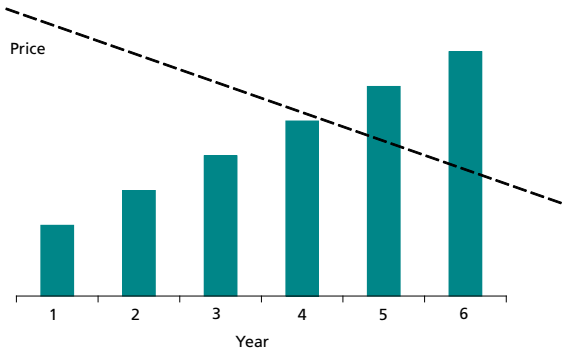


FIGURE 2
As aquaculture production of a new species goes up, price will normally go down. The challenge then is to reduce production costs at the same time to keep production profitable.



and flesh quality will be important, and work on all aspects of the rearing cycle will be needed. We very often see that increased production of farmed fish species influences their price and that with increased volume, prices must be reduced. To remain profitable, costs will have to be reduced more quickly than the reduction in price (Figure 2).

Dr. Jiaxin Chen (personal communication) has given production costs from China for cobia reared in cages. Table 2 compares these costs with those for other farmed fish. It is obvious that it should be possible to reduce the cost of cobia production to US$ 2 per kg ex. farm. However, this will take time, and improved efficiency will be required in every step of the rearing cycle.

Looking at the development of aquaculture for some other fish, the production volume for salmon has grown from nothing to more than one million tonnes over 30 years, that of cultured tilapia has grown from 700 000 tonnes in 1995 to 1.8 million tonnes in 2004, and that of Asian catfish (*Pangasius*) has risen from 50 000 tonnes to 1 million tonnes in only ten years. Liao and Leaño (2007) claim:

> *"it is projected that the cobia culture industry is very likely to exceed 1 (one) million tonnes annual production in the future. This will take more than 10 years to achieve but not as long as 30 years as cobia could become the "tropical" salmon".*

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