DOCUMENTOS DEL TALLER

Current status of world bivalve aquaculture and trade

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RESUMEN

En 2005, los bivalvos representaron el 10 por ciento en cantidad y el 7 por ciento en valor del total de la producción pesquera mundial. La producción mundial de bivalvos moluscos ha aumentado considerablemente en los últimos cincuenta años, pasando de casi un millón de toneladas en 1950 a unos 13,6 millones de toneladas en 2005. China es el principal productor de moluscos bivalvos seguido de Japón, los Estados Unidos de América, la República de Corea, Tailandia, Francia, España, Italia y Chile. En el mismo año la producción acuícola de moluscos bivalvos en América Latina y el Caribe alcanzó aproximadamente 128 500 toneladas lo que representa el 1,07 por ciento del total mundial de la producción acuícola y en cantidad ($EE.UU. 432 millones). Chile es el mayor productor en la región seguido por Brasil y Perú. Las principales especies producidas son el mejillón chileno y la concha de abanico. En 2005, las exportaciones totales de bivalvos de América Latina y el Caribe fueron 18 500 toneladas ($EE.UU. 124 millones). Las vieiras son las principales especies de bivalvos exportadas seguidas de las almejas.

ABSTRACT

In 2005, bivalves represented 10 percent in quantity and 7 percent in value of the total world fishery production. World bivalve production has increased substantially in the last fifty years, going from nearly one million tonnes in 1950 to about 13.6 million tonnes in

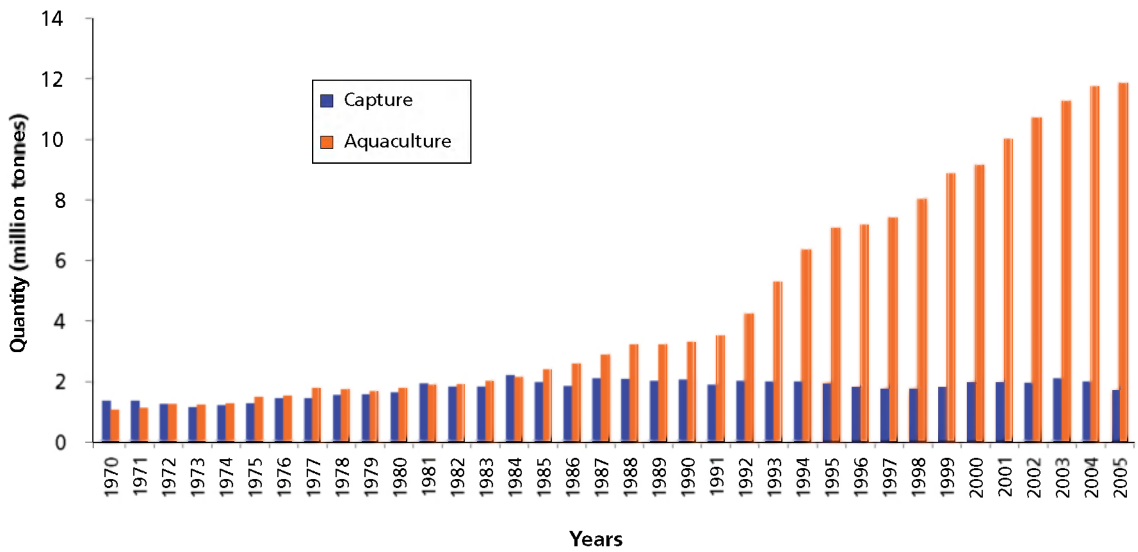
2005. China is by far the leading producer of bivalves followed by Japan, the United States of America, the Republic of Korea, Thailand, France, Spain, Italy and Chile. In the same year aquaculture production of bivalves in the Latin America and the Caribbean reached approximately 128 500 tonnes which represented 1.07 percent of the global total for aquaculture production and an estimated farm-gate value of USD 432 million. Chile has led the region in production followed by Brazil and Peru. The primary species produced are the Chilean mussel and the Peruvian calico scallop. In 2005, total exports of bivalves from Latin America and the Caribbean were 18 500 tonnes, worth USD 124 million. Scallops and pectens are by far the main bivalve species exported followed by clams.

WORLD BIVALVE PRODUCTION

In 2005, bivalves represented 10 percent in quantity and 7 percent in value of the total world fishery production, but 25 percent in volume and 14 percent in value of the total world aquaculture production. World bivalve production (i.e. capture + aquaculture) has increased substantially in the last fifty years, going from nearly 1 million tonnes in 1950 to about 13.6 million tonnes in 2005[1]. This growth is almost totally due to the increase in aquaculture production, which was particularly rapid in the 1990s (Figure 1). World bivalve aquaculture production grew from more than 3.3 million tonnes in 1990 to nearly 12 million tonnes in 2005, with an average growth rate of 8.9 percent per year during this period. In 2005, 87.3 percent of the total bivalve production in the world was cultured.

China is by far the leading producer of bivalves, with 9.5 million tonnes in 2005, all of which is cultivated, representing 70 percent of the total bivalve production and 80.2 percent of the total bivalve aquaculture production. Chinese bivalve production has rapidly increased during the last 30 years, with a particularly strong increase in the 1990s, with an average growth rate of 12.7 percent per year in the period 1990–2005.

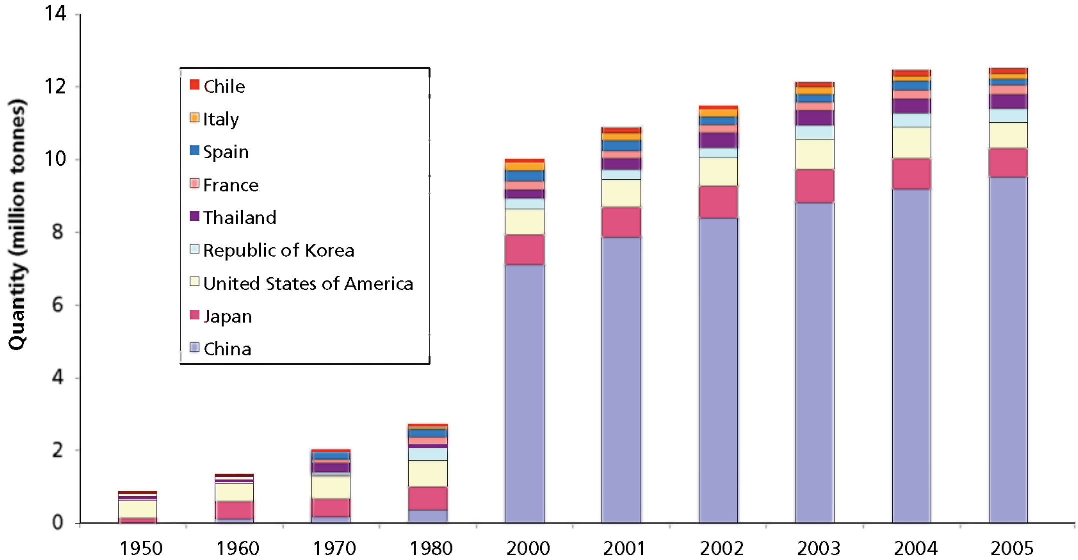
FIGURE 1
World bivalve production from capture fisheries and aquaculture from 1970–2005



Source: FAO.

[1] All totals refer to live-weight equivalents – that is, shell weight is included. Figures are based on the official FAO statistics provided by Member countries. The detailed data can be found using FishStat Plus, available at http://www.fao.org/fi/statist/fisoft/fishplus.asp.

FIGURE 2
World bivalve production by major producing countries from 1950–2005

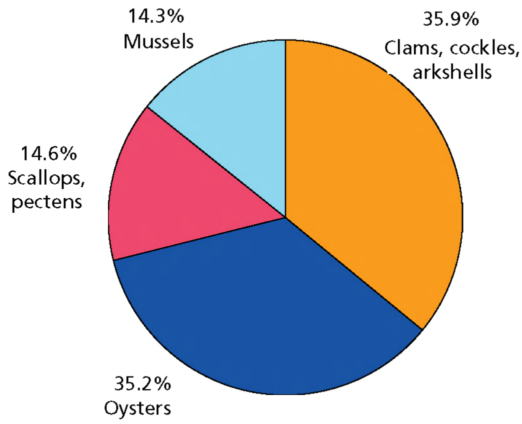


Source: FAO.

In 2005 other major producers of cultured bivalves were Japan (794 940 tonnes), the United States of America (707 200 tonnes), the Republic of Korea (389 800 tonnes), Thailand (386 540 tonnes) and France (253 300 tonnes) followed by Spain (174 716 tonnes), Italy (158 314 tonnes) and Chile (140 808 tonnes). These 9 countries account for almost 93 percent of the total world bivalve production (Figure 2).

In 2005, 35.9 percent of the total bivalve production consisted of clams, cockles and arkshells, 35.2 percent of oysters, 14.6 percent of scallops and pectens and 14.3 percent of mussels (Figure 3). While the portion from aquaculture for the same year consisted of 34.0 percent of oysters. Clams, cockles and arkshells represented the second main group of bivalves cultured (30.7 percent) followed by mussels (13.2 percent) and scallops and pectens (9.4 percent). In 2005, 94.5 percent of the oyster production originated from aquaculture. This share was 90.4 percent for mussels, 87.3 percent for clams, cockles and arkshells and 65.7 percent for scallops and pectens.

FIGURE 3
World bivalve production by major species groups in 2005 by quantity



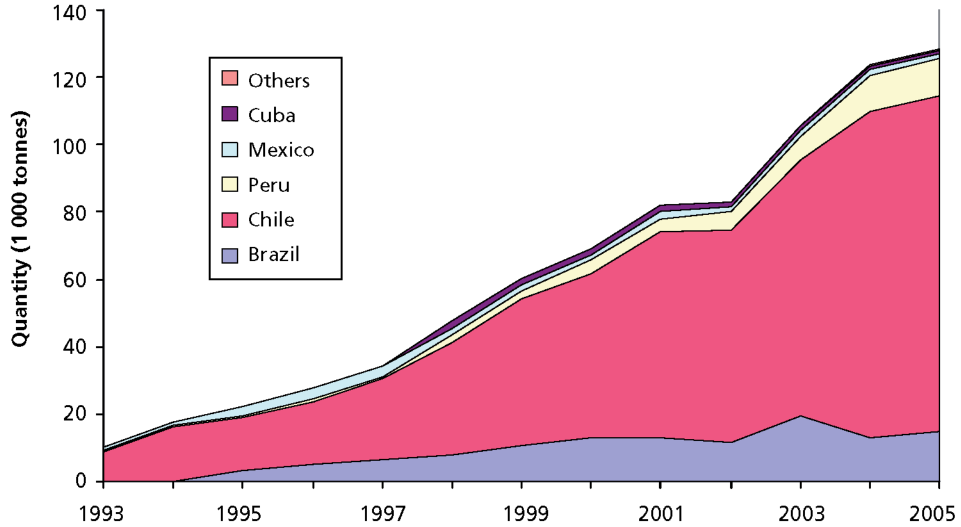
Source: FAO.

AQUACULTURE OF BIVALVES IN LATIN AMERICA AND THE CARIBBEAN

In 2005, aquaculture production of bivalves in the Latin America and the Caribbean reached 128 418 tonnes with an estimated farm-gate value of USD 432 million. This production volume represents 1.07 percent of the global total for aquaculture production of bivalves (12 011 109 tonnes). Although still a small proportion, this share of the global total has been growing steadily since 1993 when production in the region was 10 323 tonnes, or 0.19 percent of the global total.

Chile has led the region in production with 99 486 tonnes in 2005 including 81 548 tonnes of Chilean mussel (*Mytilus chilensis*) and 14 303 tonnes of the Peruvian calico scallop (*Argopecten purpuratus*) followed by Brazil and Peru (Figure 4).

FIGURE 4
Bivalve production in Latin America and the Caribbean from 1993–2005



Source: FAO.

Major species – As Chile dominates bivalve aquaculture production in the region, the primary species produced in Chile are also the primary species produced in the region as a whole – i.e. Chilean mussel (81 548 tonnes) and the Peruvian calico scallop (25 369 tonnes) (Table 1). Peru also reports substantial production of the latter species (11 066 tonnes in 2005). In Brazil, production consists primarily of the South American rock mussel (*Perna perna*) and cupped oysters (*Crassostrea* spp.). Mexico and Cuba have also reported recent oyster production exceeding 1 000 tonnes. Only three families of bivalve species are currently represented in the production statistics for the region – Mytilidae, Pectinidae and Ostreidae. Globally, another eight families have production over 1 000 tonnes, led by Veneridae (3 017 765 tonnes) and Solecurtidae (713 846 tonnes).

Comparison to capture production – For most of the period 1985–2005, capture production of bivalves in Latin America and the Caribbean has fluctuated between 150 000 tonnes and 250 000 tonnes (see Figure 2). In addition to Chile and Peru, Mexico, Venezuela and Argentina reported capture production of bivalves exceeding 25 000 tonnes. The growth of bivalve aquaculture from 1993–2005 coincided with a period of growth in capture production (1993–2001) followed by a period of a small decline (2001–2005). This might indicate that there is room for the sector to grow and an un-met demand for additional bivalves. In 2005, the share of bivalve production coming from aquaculture reached a high of 36.7 percent for the region (Figure 5).

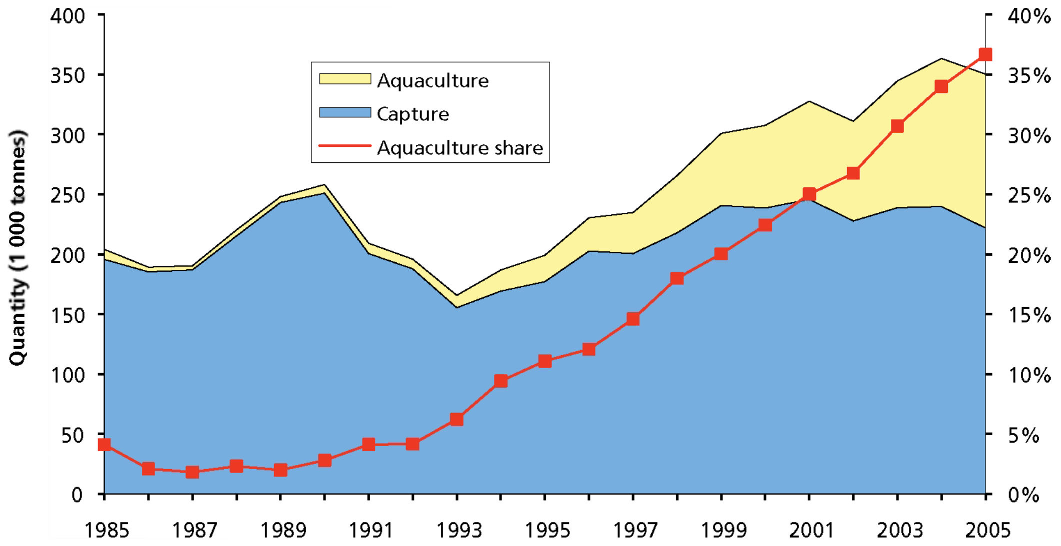
WORLD TRADE OF BIVALVES

The share of bivalves entering international trade is relatively limited, about 2.3 percent in value terms in 2005.

World exports of bivalves have increased steadily in the last 25 years, going from 124 300 tonnes (product weight), worth USD 140 million in 1976 to 459 300 tonnes (product weight), worth USD 1 808 million in 2005 (Figure 6). In quantity terms (product weight), mussels are the main bivalve species exported with 257 300 tonnes in 2005, followed by scallops and pectens (93 000 tonnes), oysters (54 700 tonnes) and clams and arkshells (54 300 tonnes). However, statistics for clams and arkshells are underestimated as these species are not separately identified by the Harmonized

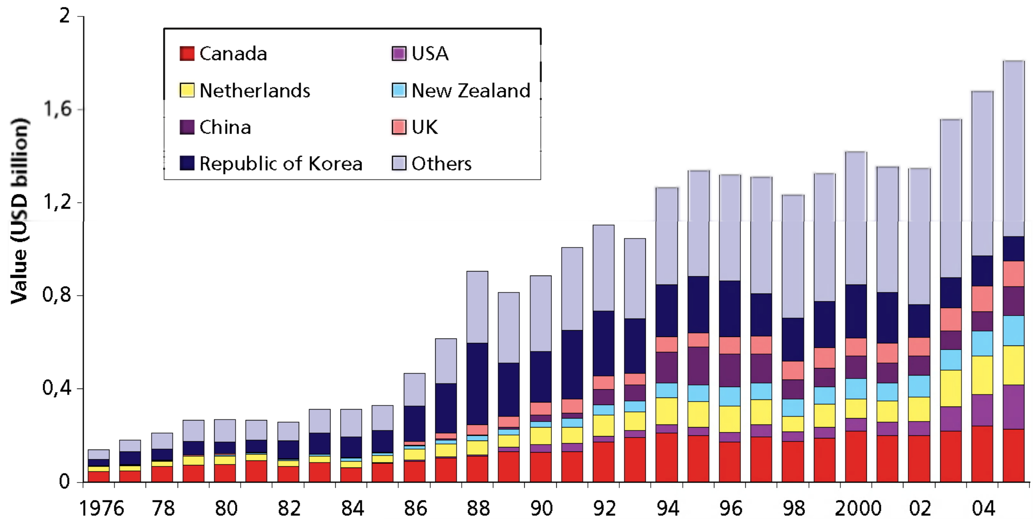
System classification as well as by many countries (including China up to 2005) in their national classification. Trade of clams and arkshells is so often recorded under "other molluscs unidentified". The real exports of clams and arkshells is estimated at about 100 000 tonnes.

FIGURE 5
Relative contribution to bivalve production from capture and aquaculture in Latin America and the Caribbean from 1985–2005



Source: FAO.

FIGURE 6
Total world bivalve exports by countries from 1976–2005



Source: FAO.

In value terms, scallops and pectens are the first (USD 811 million), followed by mussels (USD 549 million), oysters (USD 198 million) and clams and arkshells (USD 155 million, with a possible real value of about USD 300 million).

In 2005, 49.1 percent of all bivalve exports (value-wise) consisted of frozen bivalves, 38.8 percent were live, fresh or chilled, 10.7 percent in canned form and 1.3 percent were cured bivalves.

TABLE 1

Top species 2005 Production – Aquaculture of bivalves (tonnes)

World			
English name	**Nombre español**	**Scientific name**	
Pacific cupped oyster	Ostión japonés	*Crassostrea gigas*	4 497 085
Japanese carpet shell	Almeja japonesa	*Ruditapes philippinarum*	2 946 900
Yesso scallop	Vieira japonesa	*Patinopecten yessoensis*	1 239 811
Sea mussels nei[1]	Mejillones nep[2]	Mytilidae	772 559
Constricted tagelus	Sinonovacula constricta	*Sinonovacula constricta*	713 846
Blood cockle	Arca del Pacífico occidental	*Anadara granosa*	43 924
Blue mussel	Mejillón común	*Mytilus edulis*	391 210
Green mussel	Mejillón verde	*Perna viridis*	280 267
Mediterranean mussel	Mejillón mediterráneo	*Mytilus galloprovincialis*	114 264
New Zealand mussel	Mejillón de Nueva Zelandia	*Perna canaliculus*	95 000
Other bivalves	Otros bivalvos	–	523 243
Latin America and the Caribbean			
Chilean mussel	Chorito	*Mytilus chilensis*	81 548
Peruvian calico scallop	Ostión abanico	*Argopecten purpuratus*	25 369
South American rock mussel	Mejillón de roca sudamericano	*Perna perna*	12 775
Pacific cupped oyster	Ostión japonés	*Crassostrea gigas*	3 580
Cupped oysters nei[1]	Ostiones nep[2]	*Crassostrea* spp.	2 110
Mangrove cupped oyster	Ostión de mangle	*Crassostrea rhizophorae*	1 046
Cholga mussel	Cholga	*Aulacomya ater*	808
Choro mussel	Choro	*Choromytilus chorus*	504
American cupped oyster	Ostión virgínico	*Crassostrea virginica*	237
Cortez oyster	Ostra de Cortez	*Crassostrea corteziensis*	225
Other bivalves	Otros bivalvos	–	216

[1] nei = not elsewhere included

[2] nep = no especificado en otra partida

Source: FAO.

In 2005, Canada was the major exporter of bivalves in value terms with USD 229 million (12.7 percent of the total exports of bivalves), followed by the United States of America (USD 188 million), the Netherlands (USD 166 billion), New Zealand (USD 130 million) and China (USD 124 million, underestimated).

In 2005, the United States of America was the leading importer of bivalves in value terms with USD 395 million, representing 18.9 percent of the total imports of bivalves. Other major bivalve importers were France (USD 361 million), Japan (USD 217 million), China Hong Kong Special Administrative Region (SAR), China (USD 171 million), Spain (USD 156 million), Belgium (USD 152 million) and Italy (USD 106 million).

In 2005, the Netherlands was the main exporter, value-wise, of mussels, with USD 144 million, representing 26 percent of the total exports, followed by New Zealand (21 percent), Denmark (9 percent), Spain (8 percent) and Ireland (7 percent). France was the major importer of mussels with USD 103.4 million, a share of 19 percent of total imports. Other major importers were Belgium (17 percent), the United States of America (12 percent), Italy (9 percent) and Spain (8 percent).

The Republic of Korea is by far the leading oyster exporter with 31 percent of the total value of oyster exports in 2005. Other major oyster exporters, in value terms, were France (16 percent), China (10 percent), the United States of America (9 percent), Canada (7 percent), New Zealand (6 percent) and the Netherlands (3 percent). The United States of America was the major oyster importer in 2005, with USD 48.6 million, a share of 22 percent of the total. Other major importers value-wise were Japan (16 percent), China and China Hong Kong SAR (13 percent), Italy (9 percent), Spain (6 percent) and Canada (6 percent).

In 2005, the United States of America was the major exporter in value terms of scallops and pectens with USD 134.8 million, representing 17 percent of the total value of exports. Japan was the second major exporter with a 12 percent share, followed by Canada (11 percent), the United Kingdom (11 percent) and China (9 percent). In 2005, France was the leading importer of scallops and pectens value-wise, with a 24 percent share of the total, followed by the United States of America (22 percent), China and China Hong Kong SAR (13 percent), Japan (5 percent), Belgium (5 percent) and Canada (5 percent).

In 2005, Canada was the leading exporter of clams with a share of 41 percent of the total value, followed by the Republic of Korea (16 percent), the United States of America (13 percent), Chile (7 percent) and France (5 percent). Japan was the main importer with a share of 42 percent, followed by Spain (19 percent), the United States of America (17 percent) and Canada (10 percent).

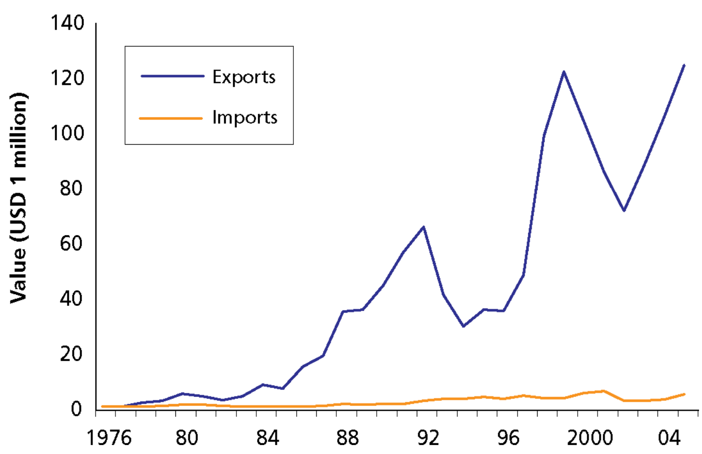
BIVALVE TRADE IN LATIN AMERICA AND THE CARIBBEAN

In 2005, total exports of bivalves from Latin America and the Caribbean (LAC) were 18 500 tonnes (product weight), worth USD 124 million (Figure 7). This export value represents 6.8 percent of the world total value of bivalve exports (USD 1.8 billion) and only 1.3 percent of total exports of fish and fishery products from the LAC countries. Exports of bivalves have shown a significant increase since the 64 tonnes, valued at USD 34 000, in 1976 linked to the steady growth in production. The major increase occurred in the late 1990s, peaking, in quantity terms, in 1999 (20 500 tonnes), followed by three years of decline and a further growth.

In 2005, scallops and pectens were, by far, the main bivalve species exported, with 12 100 tonnes (USD 100.0 million), followed by clams and arkshells (3 600 tonnes; USD 17.6 million), mussels (2 000 tonnes; USD 3.9 million) and oysters (778 tonnes; USD 2.2 million) (Figure 8).

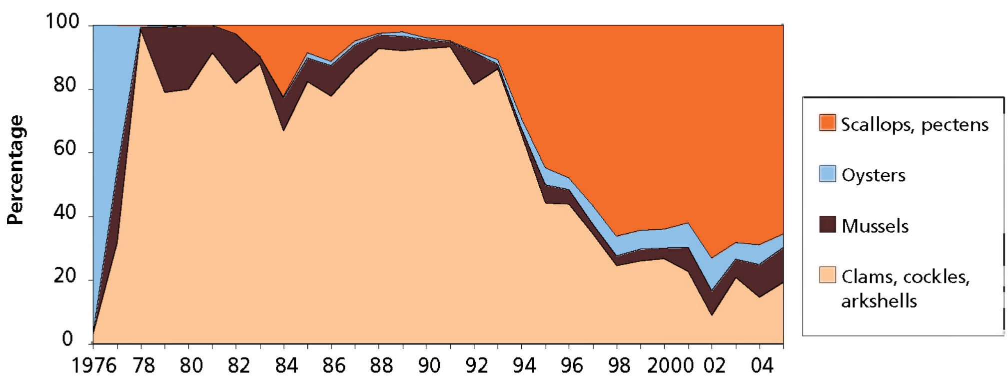
Chile represents the main exporter of bivalves with 8 300 tonnes (product weight), valued at

FIGURE 7
Bivalve trade in Latin America and the Caribbean



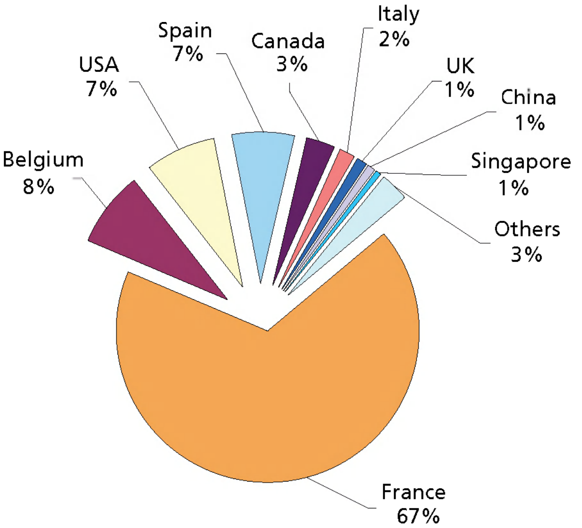
Source: FAO.

FIGURE 8
Exports of bivalves from Latin America and the Caribbean by species groups in percentage



Source: FAO.

FIGURE 9
Exports of scallops, oysters and mussels from Latin America and the Caribbean by country of destination



Source: FAO.

USD 49 million in 2005. Chilean exports have increased considerably since the mid-1990s but remained fairly stable in the following years. In 2005, 52.0 percent of Chilean exports consisted of scallops and pectens, mainly in frozen form, 35.7 percent of clams (mainly as prepared and preserved), 7.9 percent of mussels and 4.3 percent of oysters. In 2005, other major exporters were Peru (USD 37 million), Argentina (USD 35 million), followed by Uruguay (USD 1.5 million) and Ecuador (USD 0.7 million).

Europe is by far the main destination market for exports of scallops, oysters and mussels of the Latin America and the Caribbean, with France having a share of 67.6 percent (value-wise) in 2005, Belgium (8.0 percent), Spain (6.7 percent), and Italy (1.7 percent), while the United States of America absorbed 7.4 percent and Canada 3.1 percent (Figure 9).

Spain is by far the main market for exports of mussels of the Latin America and the Caribbean (LAC) countries, having a share of 72 percent of the value in 2005. Italy, South Africa, the Netherlands and the United States of America are other minor destinations.

In 2005, 84 percent of the value of the LAC exports of oysters was destined for Asian countries, with China (35 percent) as main market, followed by Singapore (26 percent) and Taiwan Province of China (19 percent). There is also an intra-regional trade with a share of 5 percent. In 1990 South Africa was the main market, with a share of 70 percent which dropped to only 8 percent in 2005.

The share of bivalves entering Latin America and the Caribbean is relatively limited (781 tonnes, valued at USD 4.5 million in 2005), representing a share of only 0.2 percent of world imports of bivalves and of 0.3 percent of total imports of fish and fishery products of Latin America and the Caribbean countries.

In 2005, 34.4 percent (value) of all bivalve imports consisted of scallops and pectens, 30.6 percent of mussels, 30.2 percent of clams, cockles, arkshells and only 4.7 percent were oysters.

In 2005, Chile was also the major importer of bivalves from other Latin America and the Caribbean producers with 143 tonnes, worth at 1.1 million, consisting mainly of clams. Other importers were Cuba (USD 0.7 million), Jamaica (USD 0.5 million), Dominican Republic (USD 0.3 million) and Barbados (USD 0.3 million). In 2006, Chilean imports of clams increased to USD 2.2 million, with Peru as the only supplier in live, fresh or chilled form and Italy as a supplier of USD 497 in prepared and preserved form.

The majority of the exports of scallops of Chile consists of frozen *Argopecten purpuratus* (Ostiones del Norte) with France as the main market (91 percent of the USD 29.7 million in 2006), followed by Italy, Australia, Belgium, Brazil, Spain and the United States of America. In 2006, there was an increase in exports of prepared and preserved scallops going from USD 15 100 to USD 117 100. In 2006, 99.9 percent of the Chilean exports of oysters (USD 1.6 million) consisted of *Crassostrea gigas* (Ostras del Pacifico) the majority of which (91.2 percent) were exported in the frozen form. In 2006, 38.6 percent of the Chilean exports of oysters were destined to Singapore, followed by Taiwan Province of China (22.6 percent), South Africa (15.9 percent), China (11.2 percent) and Namibia (10.8 percent). The majority of the exports of mussels are in frozen form. In 2006, 71.4 percent of the Chilean exports of mussels (USD 7.1 million) were destined to Spain. Other major markets were the United States of America (8.6 percent), France (5.4 percent), the Netherlands (3.0 percent), the Russian Federation (2.2 percent) and Italy (1.9 percent). In 2006, Chilean exports of clams were USD 18.0 million of which 99.2 percent in prepared or preserved form. Almost 80 percent of the clam exports consisted of the following two species *Protothaca thaca* (Taca clam) and *Ameghinomya antiqua* (King's littleneck). Spain represents the main destination market, with a share of 91.9 percent in 2006. Other markets were Mexico, Argentina, Peru, Ecuador, Colombia and Venezuela.

The bulk of the exports of bivalves of Peru consist of scallops, mainly vieiras, concha de abanico in frozen form. France represents the main destination market for these exports (81.3 percent in 2006). Other major markets are Spain, Belgium and Italy. In 2006, total Peruvian exports of bivalves were 6 290 tonnes (product weight), worth USD 46.4 million (95 percent in frozen form). In the same year, other exports of bivalves consisted in 2 tonnes of oysters (USD 12 560); 24 tonnes of mussels (USD 54 960) and 765 tonnes (USD 4.5 million) of prepared and preserved clams (79.5 percent to Taiwan Province of China).

ENVIRONMENTAL ISSUES AND BIVALVE AQUACULTURE

The further expansion and development of a sustainable bivalve aquaculture sector will require, as one major condition, the availability of suitable grounds where the environmental parameters will allow the production of the farmed species. The maintenance of such grounds will also ensure the sustainable continuity of this commercial sector. Many of the environmental concerns that the public have about finfish farms are not however issues that generally affect shellfish culture. This is largely due to the dispersed nature of shellfish farms, the absence of inputs of feed or therapeutic medicines to the environment, and the fact that shellfish farm biomass is naturally limited by the plankton availability. Shellfish culture is essentially a nutrient extractive industry, not one of net nutrient input.

Shellfish culture depends for its existence on maintaining a sustainable balance with its environment. The effect that shellfish cultivation has on the environment must not be such that the environment cannot support the production. Recognition of such limitation should result in the appropriate design of a farm, stocking rates, timing of harvesting, etc. All these factors have to be related to the site chosen and its particular environmental variables, which will be different for each site.

All human activities that take place in the environment will have an environmental impact to some extent. This term has come to resonate with the public as always having negative connotations, but what is considered to be a significant impact in one area or situation, may not be so in another. In shellfish culture the following major issues are considered to be significant: visual impact; benthic changes; introduction of alien species for cultivation; impact on local wild fauna; introduction of predators, pests and diseases; competition with other endemic species; alteration of the plankton profile; nutrient status of a water body and siltation.

Visual impact – In areas of intense bivalve farming activity such as many areas of the French and Chinese coasts, there is an undoubted impact that is considered to be a part of the scenery and a natural result of the local economy, in the same way that rows of vines, sunflowers, cabbages or bales of silage have an effect on terrestrial scenery. The industry is promoted and celebrated, and is accepted by locals and visitors alike. In less traditional farming areas the farming installations are much lower-scale, but are not yet accepted universally as a legitimate part of the scenery. This is partly because of their relative novelty and partly because of the wild nature of the landscape in which they exist. What is or isn't visually acceptable will always be a subjective matter and may change over the years. In the meantime strong efforts are made to limit the visual impact as a result of the scale of developments and their production potential is often restricted.

Benthic changes – During the production cycle of shellfish, mortalities occur, faecal and pseudofaecal matter is produced and a proportion of the farmed animals and associated fouling organisms fall off. All these will accumulate on the seabed. The rate of accumulation and the size of seabed footprint created by the farm will depend on the size and density of the farm, the depth of the bottom below the culture units, the peak current velocity and directions, and the peak wave energy. The debris that falls to the bottom is not unnatural and accumulation is often matched by natural processes of dispersal. Where there is a potential for unacceptable accumulation, design changes to a farm should be considered.

Changes to the benthos caused by siltation occur where the density of ropes, trestles or bouchot poles cause a reduction in the current velocity to the point where silt particles are able to settle out of suspension and onto the bottom. Where this is severe, it may be necessary to remove or reduce the installations temporarily or permanently. There will be changes to the species diversity on the bottom beneath a farm that may or may not be considered acceptable. They do not appear to be irreversible changes and are partly balanced by the great diversity of species that will be found growing on or amongst the culture species. Many of these crustaceans, worms, molluscs and algae become food for associated populations of fish that in turn support significant bird populations. This increase in diversity is also of course, an environmental impact, although rarely viewed as undesirable. As with visual impact above, there is a great differential between countries in what is considered to be an acceptable level of change or impact.

Alien species – Introducing non-native species into an environment carries a high risk that they may become a pest and displace native species. The introductions of Pacific oysters and Manila clams have proved to be economically highly successful and they have now naturalized in certain areas that appear to be increasing in size as climate changes take place. Introduction of non-native species has also been associated with the introduction of non-native pests and diseases that have seriously affected the native species, preventing regeneration of stocks. Mass introduction of adult or halfware stocks of alien species seems to carry an inescapable risk of importing undesirable organisms. Quarantine or import inspections do not carry the 100 percent guarantee that should be required. Use of hatchery-reared juveniles seems to be the only sensible course to take.

Non-native competitive or smothering organisms such as certain tunicates, crustaceans, molluscs and algae are also causing problems. The point of entry of these is not always known, but ship ballast water is a prime suspect. Toxic algal species may also be being spread in the same way.

Interaction with wildlife – In the Netherlands the natural seed resource utilised by the mussel industry also supports large populations of ducks, oyster catchers and other seabirds. The quantity of seed available to the farms has been reduced in recent years as more has been reserved for the birds. This has resulted in a reduction in production of approximately 50 000 tonnes of mussels. Ducks and oystercatchers are serious predators of mussels and oysters and a number of measures are used to reduce the damage. Other serious predators are crab, starfish, oyster drills and some fish. Many strategies are used to prevent predation and few of them are fully successful, so it could be said that shellfish farming supports dependent populations of other species. On the whole, however, shellfish farming coexists well with surrounding wildlife and in many cases positively enhances diversity.

Plankton profile – In area of intensive shellfish aquaculture such as the Spanish Rias, French bays or Italian lagoons, the presence of a large number of spawning adult molluscs will skew the natural profile of the plankton so that the larvae of the cultured species dominates the plankton and could lead to heavy settlements out-competing other naturally occurring species. The presence of a high population of filter feeders could also lead to a shortage of food plankton for other filter feeding species. This however has not yet been proven and is unlikely to be significant in the moderate densities found in many culture areas.

Nutrient status – The effect of large populations of cultivated molluscs has the potential to increase the rate of remineralization of organic matter that is consumed, digested and excreted by the shellfish. This apparent increase in the level of nutrients available for plankton growth has led to investigation of the benefits of polyculture of finfish, shellfish and macroalgae. High populations of shellfish also have the potential to reduce oxygen levels in poorly flushed areas. This has been noted in the clam farming lagoons in Italy and over the mussel beds in the Limfjord in Denmark.

Effects of the environment on shellfish culture – The major environmental issues to affect shellfish farmers are those concerned with water quality. These include the microbiological status of the harvesting areas, the incidence of industrial pollutants and harmful algal blooms with associated toxic events.

The microbiological status of the harvesting area is largely affected by the policies of local authorities, specifically with regard to sewerage treatment and agricultural "diffuse" pollution. Industrial pollutants (dioxins, polychlorinated biphenyls, hydrocarbons, pesticides, etc.) may be a local problem or in the case of persistent substances, they may come from further afield. Marine biotoxins may or may not be an entirely natural occurrence but they are becoming increasingly common, and regulation is becoming increasingly intensive. None of these problems are caused by the farmer but all of them have the capacity to destroy an industry and ultimately the industry may have to pay to clean them up. These are the environmental issues that most concern the industry and are the biggest threat to its long-term sustainability.

CONSUMER AND SOCIETAL ISSUES AFFECTING THE GROWTH OF THE SECTOR

Demand seasonality, lifestyle and health issues – Those countries with a long tradition of consumption are related historically to availability and seasonal quality. In popular tourist destinations demand is also seasonal and high during the summer months. On the other hand, in other regions (e.g. Southern Europe one tends to see a more continuous year round demand.

In countries where the general change in diet is away from red meat consumption and towards increasing seafood consumption, there has been a positive affect on demand for shellfish. This is particularly true in regions where seafood consumption has not always been the norm. The change in work patterns, family structure, general affluence and the cash rich/time poor syndrome of modern life has increased the demand for easily prepared or precooked ready meals, including shellfish. The demand for this type of produce is recognized and is partly responsible for the increase in supply of processed shellfish products.

Many authorities recognize the health benefits of consuming shellfish. These include its properties of low fat, high polyunsaturated fatty acids – particularly Omega 3 – and its rich source of minerals such as zinc and iron, etc. These benefits are frequently promoted to the public by trade bodies, governmental bodies and Non-governmental Organizations. Such communication needs to be seen as a long-term commitment, as the consuming public has a short memory for good news and a long memory for bad news, particularly food poisoning events.

Consumer perception – The general perception of shellfish is a positive one, particularly amongst traditional consumers. However amongst the non-traditional consumer there is continuing suspicion about the food safety issues. This more conservative portion of the public will need continued and unequivocal messages about the health benefits and safety of shellfish before they are persuaded. This should be seen as a worthwhile exercise as the non-traditional consumer represents a very large potential market. Information provided to the public tends to concentrate on the usual consumer issues of taste, value for money, ease of preparation and health benefits. Information on the method of production is occasionally provided to the consumer in a brief form. However, this could profitably be expanded upon, particularly with reference to the sustainable nature of the industry, in order to enhance a positive Public Relation (PR) image. There is widespread ignorance amongst the public and shellfish farming is currently too easily lumped in with finfish farming and consequently can suffer from the bad press that this industry sometimes attracts.

Media coverage – It appears that when all else is equal, the press will prefer a bad news story to a good news story. Likewise, the public seems to have a long memory for the downside and for every feedback story on the health benefits of shellfish, there will be hundred fictional tales about poisonous oysters, allergies to mussels, radioactive clams, etc. In countries with a traditional bivalve aquaculture industry press coverage appears to be well informed. This is no doubt a reflection of the historic economic importance of the industry and its cultural place in local society. In these countries, threats to their industry are taken seriously by the public and the media.

Impact of action groups – Single issue action groups campaigning against shellfish farms may be objecting on the grounds of visual impact, navigation issues, noise, beach debris, disturbance to wildlife, etc. While many of these issues can be subjective and not based on real evidence, it is necessary to spend time and effort to ensure that farms are complying with relevant regulations and protocols and countering with positive issues such as employment benefits, production of quality food, etc.

Retailer influence – The relationship between producers and retailers and retailers and consumers is a dynamic one that will change with the supply and demand situation. In times of shortage the supplier calls the shots and during a glut the producer becomes a price taker. For long-term sustainability of the industry there needs to be understanding by both parties of the others' needs. In the case of small producers it may be advantageous, in certain situations, to group together as larger commercial units or as cooperatives in order to achieve what the supermarket requires. The influence of the retailer on the customer is based on the way a product is presented, packaged and priced, and on the range, quality and availability of the product.

ECONOMIC SUSTAINABILITY OF THE SECTOR

Shellfish aquaculture is first and foremost a commercial business although in some areas can be considered part of a subsistence economy. The economics of the industry will vary with the normal rules of supply and demand, production costs and sales price, as these factors will be affected by the environmental sustainability and vice versa. There are many outside influences that affect the economic sustainability of the industry, most of which cannot be controlled by the industry, but must be reacted to. Some of these include:

- <u>Increases</u> in input costs of fuel, labour, transport, steel, plastics and other materials. As the industry becomes more mechanised, more dependent on production in peripheral areas and more dependent on processed product, then fuel costs become more critical. That includes fuel use in production, processing, chilled or frozen storage and transport to market.

- Decreases in production levels due to site and seed availability, poor weather, harmful algal blooms, diseases, pests, water quality problems and plankton abundance. Water quality problems have the capacity to make some production areas unusable or uneconomic. Differences in national attitudes to the risks of shellfish consumption mean that there is variation in the way that regulations are interpreted and implemented (e.g. the European Shellfish Hygiene Regulations). This can have large effects on the production and purification costs to a business. Current purification methods and strategies have evolved in response to the method of testing, despite the fact that the current test methods show limited correlation with real levels of anthropogenic pollution and actual risk, particularly in rural areas. If and when test methods are developed, that accurately shows the real health risks or their absence, could significantly change the sea areas in which shellfish culture is carried out.
- Expanding national and international bivalve markets will certainly benefit the industry as a whole however certain markets may become unstable due to increasing imports and irregular wild landings. For example, although the imports of bivalves into the European Union are currently small they are steadily increasing. Large variations in the level of imports could be a destabilizing influence on prices. Better long-term forecasting will enable strategies to be developed to deal with the impacts of such trade flows. The very large production of molluscs in China is not currently exported due to the combination of high levels of domestic demand and an inability to satisfy international hygiene standards. However, if this situation were to change, then there is a degree of potential for market disruption, although there are many analysts who expect China to become a major importing nation (like other large economic regions (e.g. the United States of America, European Union and Japan).
- If the shellfish industry is to remain economically sustainable, it must respond to changes in demographics, the economic climate, cultural habits and supply logistics. As the maintenance and increase in production levels comes more and more from peripheral areas then there is an increase in demand for time-stable, value-added products. This is also driven by the increase in supermarket outlets, restaurant chains with de-skilled kitchens, one-person households and the general move away from traditional meals prepared from raw materials. The industry must recognize these changes and understand that this type of market can change demand rapidly and requires a constant supply of new products. This requires new skills and high levels of investment in processing equipment and premises. It may also drive changes in raw material requirements, i.e. size, shape, etc. New techniques of preservation and presentation can also change the market rapidly, e.g. modified atmosphere packaging presentations.

RESEARCH PRIORITIES

Space – Shellfish aquaculture competes for space with many other users of the marine environment. If production is to be maintained then there must be no net loss of area. As some areas are taken out of production for various reasons, then new areas need to be brought into production. Research by industry and government bodies should aim to identify those areas and to provide assessment tools to help with the identification of suitable sites. This includes assessment of carrying capacity or assimilative capacity and identification of suitable methods and equipment, species and technology. Areas under research at present include offshore aquaculture and polyculture, both of which will make use of novel techniques and equipment, and have the potential to greatly increase the production capacity of the industry.

Clean water – This includes bacterial, viral, biotoxin and industrial contamination. The industry requires absence of all of these, or at least the ability to detect them with a rapid, simple field test. Some biotoxin field tests have been developed and others are under development by commercial companies.

The relationship between the indicator species, *Escherichi coli,* numbers in the water, *E. coli* numbers in shellfish flesh, the presence of pathogenic viruses, and the degree of actual risk in consuming shellfish is neither linear nor indeed fully understood. Without this understanding the current method for classification of harvest areas using *E. coli* as an indicator remains deeply flawed. The simplistic use of *E. coli* numbers in shellfish flesh may unnecessarily burden the producer with purification costs, whilst not providing the consumer with an improvement in food safety. Research to identify alternatives to the current system is following a number of avenues. Reducing or eliminating discharges of sewage would be a far more sustainable approach to increasing food safety. Indeed, the more remote from anthropogenic impact a production area is located, the higher the level of *E. coli* "pollution", due to the presence of wild animals (deer, seals, sea birds, etc.).

Absence of disease – Diseases of shellfish are relatively rare due to the fact that intertidal species have evolved in a challenging environment. Where diseases do occur, the effects are often exacerbated by stress factors such as temperature, oxygen depletion, or nutritional stress. Much of the research work on diseases has been on devising management strategies to reduce stress. Work has also been carried out on selecting disease resistant breeding lines. This has been carried out by commercial hatcheries and farms. Investigations at the genetic level are also being undertaken by academic institutions. Identification and detection of existing and previously unknown diseases is a statutory duty of the competent authority.

New technology – Development of new technologies may be driven by the need to farm in different environments, the need to reduce costs and labour, or may become possible because of new materials. Research of this nature is generally carried out by the farmer or the supplier of equipment, and often by both. Support for this type of research may also be made available by local or national Government. Examples of this type of work would include development of equipment and techniques for offshore installation, new methods of suspended oyster culture, and novel mussel growing systems such as ladder ropes.

Markets – Market research into customer preferences, buying trends, demographic changes, etc., are usually carried out by industry and by support governmental bodies (e.g. Seafish in the United Kingdom; Globefish network). This type of data, combined with results from research on the health benefits of shellfish consumption, can be used by industry in developing marketing strategies.

FUTURE RESEARCH NEEDS

There is a wide spectrum of research topics that need to be addressed in the future if the industry is to expand, remain sustainable and financially viable.

One major area considered of great importance is research on biotoxins. The past fifteen years or so has seen an increase in detection of previously known and more novel toxins. Test methods and precautionary control measures have often been less than acceptable. A more rational and risk-based assessment needs now to be made of current and future needs. Test methods need to be further improved, preferably into rapid field tests. Permissible levels should also be re-examined and toxin removal methods studied further. In addition, early warning systems should be refined.

Collection of data on levels of nutrients, temperature, salinity, plankton abundance, organic mater, turbidity and growth rates should be continued and increased. This is an area where industry can be of much assistance in the collection, but collating of the data should be a Government task. A long-time series of information would show any trends that could help with long-term production forecasting, business feasibility studies, site selection and market planning.

Although shellfish farming has been around for a long time, in terms of stock selection it is only just beginning. Most seed supplies, particularly of mussels, currently come from the wild but there are opportunities for hatchery production to select for certain characteristics such as growth rates, disease resistance, shell shape, salinity and temperature tolerance, meat content, age and time of sexual maturity. The ability to select for these characteristics may be particularly important if climate changes occur faster than the natural adaptation of wild stocks.

New species for aquaculture are under investigation by academic and commercial interests and this could be increased. Europe has relatively few species under cultivation compared with China and North America, but with the proper precautions and controls, this could be increased. Polyculture of shellfish with finfish, macroalgae and sea urchins have all been trialled in various places and are commonplace in many countries in the Far East.

Research into non-food uses for shellfish crops and wastes may provide new markets for the industry and enhance profitability for existing production. Many marine organisms contain bioactive compounds that could be useful to the food additive and pharmaceutical industries.