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DEVELOPMENT AND CURRENT STATUS OF ABALONE AQUACULTURE IN CHILE

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ABSTRACT Abalone aquaculture is rapidly developing in Chile although this mollusc does not occur naturally in this country. The red abalone Haliotis rufescens was introduced in 1977 and the ezo abalone Haliotis discus hannai in 1982. After several years of research and development, the industry began in 1992 and Chile is currently the fifth producer of cultured abalone in the world with 304 tons in 2006. Twenty five companies are involved in this Chilean industry, culturing mainly red abalone. Most of the farms in the North include hatcheries and land-based grow-out operations, whereas most of the in-water grow-out facilities are located in the South. All farms in Chile use algae as the main food for growing abalone, but artificial feeds are also used in some land-based operations in the North. The average size of abalone harvested in Chile is 8 cm (100–120 g) after 3–5 y in culture systems. Whole frozen abalone (shell on) is the most important form of this Chilean product (82% in 2006) and the main market is Japan (90.2%). Abalone production has increased at a rate of around 50% per annum over the last 3 y. This development is expected to continue in the next years, fostered by favorable geographic, economic, and environmental conditions as well as an important government support to invest in abalone. A survey among producers revealed that feed availability and quality is currently considered a key issue to further develop this industry in Chile.

KEY WORDS: abalone, Chile, *Haliotis rufescens*, *Haliotis discus*

INTRODUCTION

Abalone aquaculture over the last decade has increased its share of the world abalone market with the decline of abalone fisheries. Abalone culture technology is now well established in several countries, and the industry can be considered to be entering a maturation phase. The most important producing countries include China: 5,000 tons p.a., Taiwan: 3,000 tons p.a., South Africa: 700 tons per annum (p.a.), Australia: 450 tons p.a., Chile: 254 tons p.a., USA: 240 tons p.a. and México: 40 tons p.a. (Different sources from the VI International Abalone Symposium, Chile 2006).

Chile is among the top ten aquaculture producers in the world with a production volume of 694,000 tons per year and a value of 2.8 billion dollars per year (FAO 2006). Aquaculture is an important income source for the country's State percentage of gross domestic product. Abalone were introduced as an option to diversify the aquaculture activity in the country. Chile has a long coast of around 5,000 km with seawater temperature suitable for abalone culture and many protected coastal areas, particularly in the South. This, together with a competitive labor cost and a good supply of kelp as food for abalone, has helped to develop a promising abalone aquaculture industry in the country (Godoy & Jerez 1998, Flores-Aguilar 2003).

The abalone aquaculture industry initiated in the 1960s, by a small group of individuals mainly in United States and Japan, who were able to successfully spawn abalone and rear the larvae, juveniles, and young adults by the early 1970s. (Ino & Harada 1961, Owen et al. 1971, McBride 1998). The Chilean abalone industry began a decade later. Red abalone *Haliotis rufescens* was introduced in 1977 with a few adults for experimentation in closed systems by Fundacion Chile and Universidad Catolica del Norte (Viviani 1981, Godoy et al. 1992). Commercialization of the industry began in 1992, when an environmental impact assessment study done by Fundacion Chile was approved, and red abalone culture in the sea off Chiloé Island in the X region was authorized. (Fig. 1) The first company permitted to commercially culture abalone was Campos Marinos S.A., a subsidiary company of Fundacion Chile (Ziomi 2001). The Japanese or ezo abalone *Haliotis discus hannai* was introduced by Universidad Católica del Norte in 1982 (Rivera 2001). This University with the aid of Japanese experts adapted the technology for the ezo abalone and after 1996 was able to transfer abalone to several companies in the north of Chile (Rivera 2001).

Abalone culture in Chile is ruled by a resolution of September 30, 2002, which allows the red abalone (*Haliotis rufescens*) and the green abalone (*Haliotis discus hannai*), to be cultured in closed circuit land-based operations, and specifically the red abalone is allowed to be cultured in suspended systems in the sea, between latitudes 41°21′55″S and 46°0′00″S (between Seno del Reloncavi and Skyring Peninsula). Since 2004, the culture of green and red abalone is permitted in-water but only in the III and IV regions, and the stock has to be a single-sex individuals and sited over a soft substrate area, (Subpesca 2006). Only one company complies with this regulation and is now growing only female abalone in the sea in the III region.

With the growth in investment in abalone culture in Chile, producers have begun to organize around common issues. Two abalone workshops were held in Puerto Montt (Ifop 2001, Flores-Aguilar 2003) in which the producers discussed the industry constraints in Chile. Most of farmers were from the South and in-water growers. Constraints were ranked and at that time and the top priority was to standardize abalone seed quality, followed by the development of manufactured diets, optimizing kelp culture to feed abalone, improving grow-out system technology in the sea, and to standardize the quality of product to access the market. On the second occasion the rank

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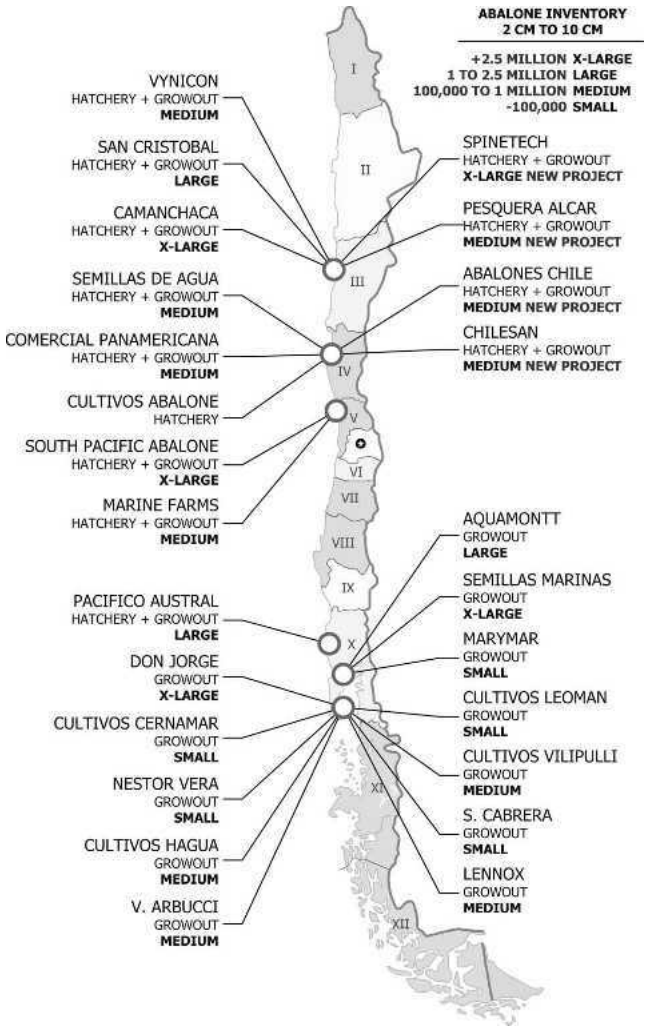

Figure 1. Location of abalone facilities in Chile, with notes about its abalone inventory, political regions of the country are included as geographical reference.

was similar, but the establishment of health programs was now seen as one of the priorities.

This article examines the current status of abalone aquaculture industry in Chile. It includes the current production and technology used in the North and South of the country, physical sites, feeds, production, current market and educational needs of the industry, as well as constraints identified by producers and experts.

METHODS

A survey of the abalone culture and research laboratories in Chile was conducted by telephone, using a similar methodology to McBride (1998). One individual at each facility was interviewed and asked a series of questions in five categories, namely: physica site, feeds, production, constraints, and research needs. Questions about the site included location, type of facility in operation, size, years in operation, abalone production, number of employees, and major expense items. Feed data collected were the amount of kelp used per week and information on the use of prepared diets. Production considerations consisted of species cultured, water quality characteristics, market location, size of the growout system, production of market-sized abalone, and number of seed produced. Producers' views on constraints and research needs in the survey were solicited during the interview.

Seed abalone were defined as animals of 17–28-mm shell length; market-sized abalone as 80–95 mm in shell length and 90–180 g in whole live weight. A hatchery was deemed to consist of a broodstock area, a spawning area and larval rearing system, and a nursery facility for rearing abalone from the postlarval to juvenile seed size animal size (17–28 mm).

A total of 24 interviews were conducted: 20 with commercial farmers, 2 consultants, and 2 with abalone experts from research and development institutions.

RESULTS

The survey revealed that 25 companies are involved in abalone culture in Chile (Tables 1 and 2). All were in a development phase, both in respect of infrastructure and building up their abalone stock. The number of commercial abalone farms was verified by comparison with the list of registered marine farmers (Sernapesca 2006), which revealed that three farms had not yet completed the permitting process.

The interviews confirmed that two species of abalone are commercially cultured in Chile, visibly; the ''Japanese'' abalone, *Haliotis discus hannai,* also commonly known as ''ezo'' or ''green'' abalone, which is cultured exclusively in the North of the country; and the red abalone, *Haliotis rufescens*, which is cultured in the North and South. The survey revealed a shift from Japanese of ezo abalone to red abalone. Most of the older farms, which had been in existence for longer than five years, had started with Japanese or ezo abalone but at the time of the survey, there were only 3 farms of the 13 land-based farms still culturing the ezo abalone.

Most of the abalone farms in the North were land-based grow-out operations, with only one farm possessing both land-based and in-water growout facilities (Table 1, Fig. 1). An important characteristic of the farms in the North is that almost all of them were fully integrated, possessing a hatchery, nursery and grow-out operations. One farm was just a seed production facility. Twelve of the 13 farms in the South were in-water grow-out operations, with only one performing land-based grow-out (Table 1, Fig. 1). There are 13 land-based production facilities and of this number only one is in the South, the rest are in the North. Only four of the farms in the South possessed a hatchery and nursery. Of these, the hatchery/nursery of two of the larger firms from the South was located in the North, the other two firms, one big and the other small, had hatcheries in the South that were still at a research and development scale.

Most of the land-based growout firms are new, with 6 of the 13 land-based farms have been in operation for less than three years. This meant that they had not yet completed a full production cycle with their own juveniles. Most of them had purchased seed from another grower to speed up the production and start selling product in a shorter lead time.

Producers reported that the abalone remain in the nursery for between 3 and 10 mo and are then introduced to production systems at different sizes, dependent primarily on the type of culture system used. Land base systems place abalone of 10–15 mm shell length into the production system, and the abalone remain there for 24–48 mo. In-water culturists initially stock young abalone of 17–24 mm in their systems. The abalone

TABLE 1.

Registered abalone aquaculturist in north of Chile.

Company	Size Operation	Operations	Haliotis Species
North land-based			
Vynicon	Medium	Seed production land-based Growout	*Haliotis discus hannai*
C.M. San Cristóbal	Large	Seed production land-based Growout	*Haliotis rufescens*
Marine Farms	Medium	Seed production land-based Growout	*Haliotis rufescens*
Semillas de Agua	Medium	Seed production land-based Growout	*Haliotis rufescens*
Comercial Panamericana	Medium	Seed production land-based Growout	*Haliotis rufescens*
Cultivos Abalone	Large (hatchery)	Seed production land-based Growout	*Haliotis rufescens*
South Pacific Abalone	X-Large	Seed production land-based Growout	*Haliotis rufescens*
Chilesan	Start-up	Seed production land-based Growout	*Haliotis rufescens*
Abalones Chile	Start-up	Seed production land-based Growout	*Haliotis rufescens*
Pesquera Alcar	Start-up	Seed production land-based Growout	*Haliotis rufescens*
Spinetech	Start-up	Seed production land-based Growout	*Haliotis rufescens*
North land-based and in-water growout			
Pesquera Camanchaca	X-Large	Seed production (North) In-water (special containers) and land-based Growout	*Haliotis rufescens*

remains in the growout systems 3–5 y from larvae to market size, the range reflecting the variability in growth rates. The total seed production in Chile during 2006 was 10.6 million abalone with an average size of 20 mm shell length.

Seed production technology on most of the farms was based on the Japanese plastic plate system for larval settlement. Plates are normally preconditioned with naturally occurring diatoms, however cultured microalgae was starting to be used on three farms to improve survivorship and productivity of postlarvae and early juvenile per plate. The United States and Mexico round tank system was used in 3 of the 12 seed production facilities.

In water growers normally use a barrel culture system, and only the larger production companies with inventories over 2 million abalone used cage based growout systems. These were either plastic moulded cages or iron galvanized structures covered with netting.

Physical Sites

The location of commercial abalone farms in Chile are illustrated in Figure 1. Chile is divided into 12 regions and a metropolitan region where the capital Santiago is located. Abalone farming occurs in the III, IV, V (the ''North''), and the X (''South'') regions.

Abalone farms in the North are characterized by land-based operations employing a substantial infrastructure with many fiberglass raceways tanks and integration of all phases of production; two even possess state of the art liquid nitrogen fast freezing processing plants situated either on-farm or nearby.

A total of 364 hectares of ocean floor and coastal land is currently used for abalone aquaculture in the country (Sernapesca 2006). Most of the farms are located in rural areas, two are in urban areas.

Chilean abalone farms used 224 people in full-time positions in 2006. An additional 62 participated in part-time work especially in the South where most growers share their personnel with other culture operations with mussels or oysters. Labor was identified by 16 of the 23 Chilean growers interviewed as their largest expense.

In addition to labor, the major production expenses were feed, power, marketing, regulatory compliance and fees. Feed was considered the second biggest expense by 18 growers, and power was identified as the third greatest expense by nine land based growers.

A special production consideration was abalone seed acquisition. All growers in the North produced their own seed, whereas in the South all farms purchased seed from companies in the North, at a price that fluctuated between US$0.27 to $0.44, depending on size, number of seed purchased, advance payment, and company policy.

Water quality was generally not regarded as a problem by abalone growers. In the North red tides were reported to occur occasionally, with *Gonyaulax spp* the main algal species involved, but all companies had developed good management systems and has installed filtration systems that controlled the problem. One farm in the third region experienced abnormally low oxygen seawater conditions, as low as 2.3 mg per liter, on certain days in summer. They solved the problem by installing an automatic oxygen production system on the farm. One farm originally in the South reported an occasional problem with red tides, but now moved to the North. Most of the land-based abalone aquaculture farms in Chile monitored water quality as temperature and oxygen once a day, and salinity, phytoplankton, and bacteria at least once per month. In compliance with the regulations of the federal agencies (Decreto Supremo No 90/1996. Ministry of Economy), levels of suspended solids, oxygen, ammonia, and temperature among others have to be continuously monitored. This exact monitoring requirements and their frequency however varies according to size, location of the farm, and type of feed used.

Farms routinely record ambient seawater temperatures, which range from 12°C to 21°C in the III region, 10°C to 19°C in the V and IV region, and 7°C to 16°C in the Southern X region. From December to March more extreme temperatures may be recorded, often above 20°C, especially in the third region. El Niño is a concern among producers particularly in the North, especially because red abalone is being cultured, but no important events have been recorded in the years of production.

TABLE 2.

Registered abalone aquaculturists in the South of Chile.

Company	Size Operation	Operations	Haliotis Species
South Land-based			
Pacifico Austral	Large	Seed production r-r&d (South) land-based Growout	
South In-water			
Don Jorge	X-Large	Seed production (North) In-water Growout (iron coated cages)	*Haliotis rufescens*
Sergio Cabrera	Small	In-water Growout, barrels	*Haliotis rufescens*
Lennix	Medium	In-water Growout, barrels	*Haliotis rufescens*
Cultivo Cerna Mar	Small	Hatchery (South) Growout	*Haliotis rufescens*
Nestor Vera	Small	In-water Growout, barrels	*Haliotis rufescens*
Cultivos Hagua	Medium	In-water Growout, barrels	*Haliotis rufescens*
Aquamontt	Large	Seed production (North) In-water Growout (cages)	*Haliotis rufescens*
Semillas Marinas	X-Large	In-water Growout (plastic cages)	*Haliotis rufescens*
C. M. Leoman	Small	In-water Growout, barrels	*Haliotis rufescens*
Vincent Arbucci	Medium	In-water Growout, barrels	*Haliotis rufescens*
Cultivos Vilupulli	Medium	In-water Growout, barrels	*Haliotis rufescens*
Marymar	Small	In-water Growout, barrels	*Haliotis rufescens*

Abalone farms are obliged by law to perform health inspections on their abalone twice a year, which is reported to the government agency

Feed

All farms in Chile use algae as the main food for growing out abalone. In the North, three brown algal species, from the order Laminariales are collected or harvested for abalone aquaculture. The species are *Lessonia trabeculata*, *Lessonia nigrescens,* and *Macrocystis integrifolia*, with *L. trabeculata* being the most abundant.

In the North there is a regulation that includes a closed period for 18 mo starting from September 29, 2005. In terms of this regulation, only certain companies may harvest kelp and they have to comply with scientific management regulations to maintain the sustainability of the resource. Most of this kelp is harvested at low tide and is cut with a knife by fishermen working for these companies.

In the South, the kelp *Macrocystis pyrífera* is the most widely used algal species to feed abalone. The *Macrocystis* is harvested from small boats and cut with a knife. The seaweed is collected manually by staff on the small farms, whereas the bigger companies pay local fishermen to supply the algae. *Macrocystis* is abundant in summer, but almost disappears in winter forcing farmers to purchase cultured red algae *Gracilaria chilensis*. Whereas there is an ready supply of *Gracilaria* in the South, its price is double that of *Macrocystis* and growers claim that *Macrocystis* produces much better abalone growth rates. No kelp harvest permits are required in the Southern regions.

Artificial feeds are used in land-based operations in the North, both in nursery and in the grow-out operation. At four land-based farms, abalone of all sizes receive a combination of artificial and kelp diet.

No manufactured diets are used on the in-water farms because of environmental regulations restricting the siting of aquaculture operations using formulated feeds. As a result of the large-scale salmon culture in the region, aquaculture operations using pelleted feeds are deemed "intensive" farms and sea concessions will only be granted if they are a minimum of 2.8 km from neighboring concessions. This makes it very difficult to find suitable areas for abalone culture, which comply with this regulation. As a result all farms in the South use seaweeds as feed.

Production

In 2006, 304 tons of abalone were produced (Chilean Customs 2007), with a value of US$6.840 million. The average size of abalone product from Chile is 100–120 g, which equates to approximately an 8-cm sized abalone. Cultured abalone production has increased at a rate around 50% per annum over the last 3 y (Fig. 2). This rate of increase is expected to continue for the next five years at least, because many of the existing farms are building up their inventories. In 2005, 254 tons where produced in the country, 180 tons in the North and 74 tons in the South (Chilean Customs, 2006).

The abalone main markets are Japan (90.2% of Chilean exports), USA (6.3%), Taiwan (2.4%), with other Asian countries accounting for the rest of the Chilean exports.

By far, whole frozen abalone (shell on), was the most important form of Chilean product accounting for 82% of the product in 2006; live abalone is second at 16% of production, and canning third at 2% (Chilean Customs 2006).

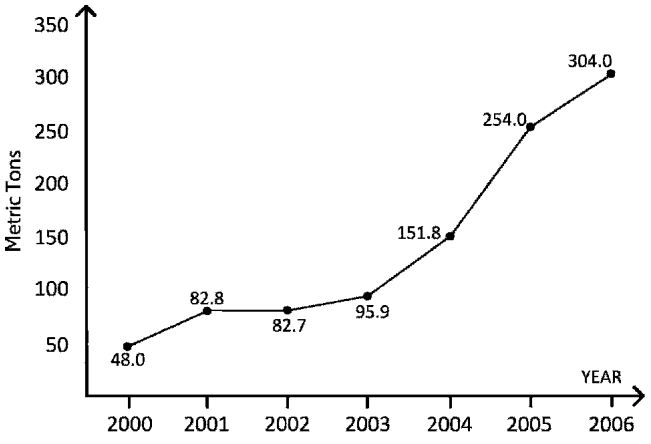

Figure 2. Chilean FOB abalone exports in metric tons.

The export price of abalone from Chile was determined by dividing the total tonnage of fresh and frozen abalone exported, free on Board (FOB) Santiago by the total value (Fig. 3). This value doesn't include expenses such as transportation to the Far East, insurance or packing material. The highest price was in 2005 and 2006 with US$29.2 for average fresh product (live), and 2005 was also the highest for frozen product US$24.3. The minimum price was in 2002 for both fresh and frozen product.

The proportion of abalone exported from the Chilean regions is shown in Figure 4. The highest production from the III region accounting for 50% of the national production. Regions IV, V, and 10 each contribute between 9% and 20%.

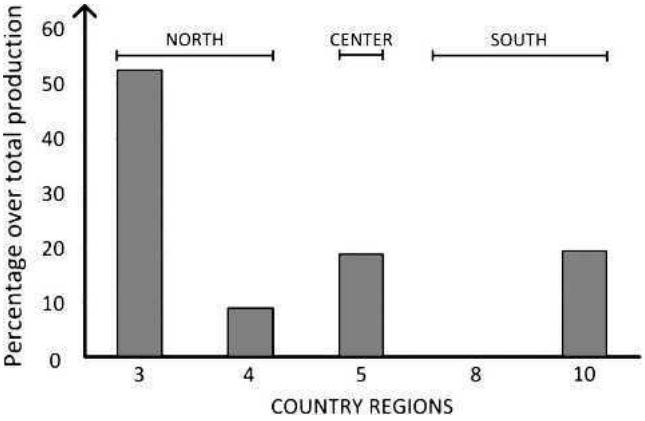

Figure 4. Regional abalone production (percentage of total production) until November of 2006.

Constraints

To better understand the nature of the constraints expressed by producers, it was necessary to separate land-based from in-water farms, and from the growers in the North from the growers in the South.

From the land-based farmers, 9 of 13 considered abalone feed to be the biggest constraint for the industry. Six producers were searching for a better supply of algae as the solution to feed supply, whereas three companies were of the opinion that a better manufactured diet was the way forward for the abalone culture industry.

The second ranked constraint for land-based farmers was less clear; five firms considered that the market has to be addressed in an associated way, to establish a minimum price for Chilean abalone, among other measures.

Four other farms regarded land-use conflicts as a constraint to the development of the industry, and were of the view that certain local government authorities gave preference to tourism industry development in their region over aquaculture. Seven companies also expressed their concern about over-regulation of the abalone farming activity. This is also a problem for other aquaculture sectors (i.e., mussel farmers).

For the in-water farmers in the South, most of whom purchased abalone seed from the North, seed quality was considered to be the most important constraint by most (9 out of 12) respondents. This was followed closely by algal feed supply. All producers regarded seaweed supply to be a very important issue, but for five small growers it was not as high a priority as seed quality, because they were currently able to find enough kelp to sustain their operations.

Another important constraint was that 6 out of 12 in-water farmers were of the view that they had had regulations imposed on them that had been designed for other cultured species, which does not necessarily reflect the needs of the abalone-farming sector.

Five of 12 in-water growers considered the 400-m buffer distance, required by law between extensive aquaculture leases (those not using manufactured diets) to a major constraint to the development of the industry, because it is very hard to find areas to comply with this requirement.

Among small mussel, oyster, and algae farmers planning to enter the abalone business, the main barrier was the long time to the first harvest, and the relatively large capital requirement until the first sale. Other reasons for not investing in abalone culture was poor knowledge of the abalone farming business in general, the common belief that abalone technology is still under development, and the uncertainty of natural food supply.

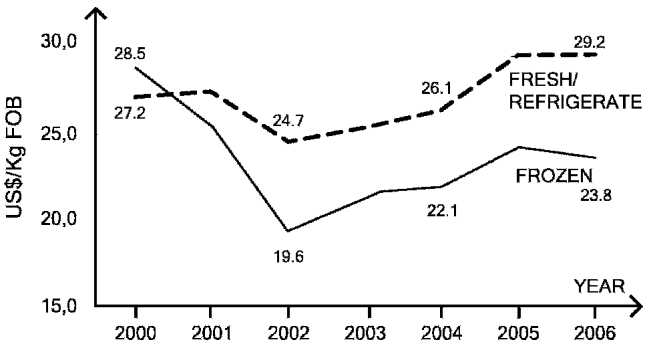

Figure 3. Value of fresh and frozen abalone exports (US$/Kg FOB).

Research and Education

Most farmers in the North and South agreed that research on feeds was the most important research required (14 out of 20 respondents). Farmers from the North land-based operations would like to see more research in the development of a formulated diet. Quality and price were the main elements to be considered in choosing a suitable feed. Farmers in the North that were interested in algae diets were of the opinion that algal production technology was ready to be scaled up to supply enough algae to abalone farms.

In the South, 7 out of 12 producers expressed the need for more research on kelp culture. Only three producers regarded the development of recirculation systems as important, but seven land-based farmers confirmed that they were performing some research into seawater recirculation systems on their own farms. The farmers of North and South viewed research on diseases as the second most important research issue to be addressed. There were other subjects such as processing technology, genetics, and single sex production that were mentioned as important areas to research.

DISCUSSION

Despite initiating abalone farming a decade later than many of the Chile's competitors, the country has successfully imported

and adapted the abalone production technology. Institutions such as Fundacion Chile and Universidad Catolica del Norte and the abalone farming companies have been the responsibility of establishing abalone farming technology in the country.

The 2006 survey revealed that Chile is the fifth biggest producer after China, Taiwan, South Africa, and Australia. As mentioned previously, favorable geographic, economic, and environmental conditions make it a perfect location for a prosperous abalone industry.

Chile has a significant potential to increase its abalone production because of the numerous areas with low population density that are ideal to produce abalone. In the South it is possible to start an in-water farm without the high infrastructure costs associated with land-based operations. Other positive factors include government support to invest in abalone, with relatively low conflicting activities for coastal or ocean use.

Godoy and Jerez (1998) mention that initially the principal interest to invest in abalone culture came from salmon farmers. Interestingly, the survey revealed that in 2006 only three of the existing firms had salmon farming as their origin. Eight of the 25 producers had a mussel farming background and the rest invested in abalone without any former ties to aquaculture or even fisheries.

Abalone farming is still a young industry, with 70% of the farms in operation for less than 5 y, so production of red abalone is expected to increase rapidly, along further development of the technology.

Even though the Japanese abalone *Haliotis discuss hannai* was introduced a long time ago in the country, it is interesting to see that it has not adapted well to the production conditions. Possible explanations are that natural Chilean algae is not an appropriate as food for this species, it possesses a poor natural resistance to diseases, in particular parasites such as shell boring polychaetes, is susceptible to stress and responds poorly to handling. It should be noted that Chilean algal feed is completely different to the countries were *H. discus hannai* occurs naturally such as Japan, China, Korea.

Red Abalone in Chile's culture is allowed in suspended in-water systems in the fjords and channels of the south around Puerto Montt and Chiloé Island as a result of the environmental impact study performed for this species. Japanese however abalone are not attractive to the Southern Chilean growers because of colder temperatures experienced in this region and the poor growout history of this species in the North.

Planned production from individual farms ranges from about 5–300 tons/y. One farm reported that it is planning a 1,000 tons/y production, and this could be expected because salmon farming revenues per company exceed US$ 100 million/y and 1,000 tons/y representing around US$ 26 million dollars. A few years ago 100 tons/y was the common target, but now companies aim for much higher production.

Some growers are planning to produce a little as 5 tons/y but this is a secondary business for them, because the major income is from mussel or other farmed products.

Abalone remain in the grow-out systems for three to five years from larvae to market size, the range reflecting the variability of growth. The growth rates of abalone in central and Southern Chile is very similar to those reported in the United States and Mexico, however in the North the average growth rate of 2.5 mm per month for red abalone is higher than in these other countries. A higher average of the year round temperature in the North seems to explain this higher growth rate.

Companies in Chile are very interested in producing in the near future a bigger individual sized abalone for the international Asian market, with a unit weight of 180 g or more.

The total seed production in Chile was 10.6 million units of an average size of 20 mm during 2006. Growers in the South argue that quality of the seed is an important problem they are facing because there is no way of knowing if they are receiving the fast growers or the slower growing tails from the stock. Small farmers in the South using in-water systems consider seed quality as the main constraint, but price of seed is also important. Big abalone companies in the North don't see the Southern in-water farms as competition and will eventually be keen to buy product from them.

Chile's environmental standards and regulations are at an international level, but many regulations may not be well suited to abalone. For example, little is known of the mechanism of toxicity by red tide algae on abalone and yet all harvested abalone must be analyzed for toxin content. This represents a large, and possibly unnecessary, expense for farmers. Similarly, farmers in the North reported difficulty in complying with the regulation requiring single sex abalone in the in-water culture systems, because it is difficult to separate juvenile male and female abalone by eye. They are required to send a sample for histology to guarantee a maximum of 95% same sex to comply with the regulation. This costs a lot of money, requires abalone they can ill-afford to sacrifice, and the current technique of sexing them by eye doesn't give them any assurance that they will meet the requirement.

There is an active health program administered by the authorities under which farms must be monitored every six months, based on a high risk disease classification list for aquatic species (Subsecretaría de Pesca Resolución No 1.496, of May 31, 2004). The monitoring includes prevention measures, as well as disease control and eradication measures. The Chilean abalone sanitary situation is deemed to be healthy, some parasites are present and closely monitored, but none of these have yet had a serious impact on the farms.

All of the farms are located in rural areas, close to small towns. This is very different from California (McBride 1998) where many farms that are situated in urban locations.

The survey revealed that most of the product (78%) originated from the North, and 22% from the South. Part of the reason for this is that many farms in the South are owned by mussel growers, which include abalone as a secondary business at their culture site. Interestingly they consider abalone farming as a back up plan to supplement their incomes when mussel price is low.

By far, whole frozen abalone (shell on), was the most important form of presentation of Chilean product. The high cost of transporting live abalone by air shipments to the Far East increased production costs, and farmers find it more convenient to ship their product frozen by sea.

The export price of abalone from Chile is slightly lower compared with other competitive countries, which could be explained by some Chilean producers not having good networks in the international markets. Also being new companies they are accepting lower prices to access the market.

Since the abalone growers workshop discussions of 2001 and 2003, feed supply remains the major concern for the farmers.

There are many manufactured feeds that have been imported or developed in the country at an experimental level, but they are still not widely used especially in the growout system where the significant amounts are needed. The growth rates obtained on these feeds and their prices do seem to have satisfied the farmers' requirements for commercial adoption of these products. Thus most farms have set up their culture systems based on algal feeds. There is a concern about the medium to long term supply of kelp. There were only two farmers that were not concerned, because they were the only farms on a long coast where there were no competitors for the kelp resource. Other shore-based growers considered that the solution was the development of a domestic manufactured feed supply. They consider that quality and a reasonable price, around $2–3 per kilogram, are two key aspects to consider.

In conclusion, the abalone industry is expected to grow in-water and in land-based farms, both in the North and the South as the basic commercial technology is now well established and Chile possesses favorable environmental, economic, and institutional conditions. The survey revealed that feed availability and quality is currently the key to the development of a substantial abalone culture industry in Chile.

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LITERATURE CITED

Chilean Customs. 2006. Información estadística de exportación. www.aduana.cl.

Chilean Customs. 2007. Información estadística de exportación. www.aduana.cl.

FAO. fisheries Technical Series. SOFIA- State of World Aquaculture: 2006. www.fao.org/docrep/009/a0874e/a0874e00.htm.

Flores-Aguilar. 2003. Gestión para el desarrollo tecnólgico de cultivo de abalón en Chile. i-mar Research Centre. Puerto Montt, 15 de Noviembre del 2002. Chile. 28 pp.

Godoy, C., G. Jerez & F. Ponce. 1992. The introduction of abalone into Chile. In: S. A. Shepard, M. Tegner, & S. Gúzman del Próo, editors. Abalone of the world. Biology, fishery and culture. Blackwell Scientific Publications Inc.: Oxford, UK. 608 pp.

Godoy, C. & G. Jerez. 1998. The introduction of abalone in Chile: Ten years later. *J. Shellfish Res*. 17:603–605.

Ifop 2001. Seminario Taller Análisis y Proyecciones del Cultivo de Abalón en Chile. Diciembre 2001. Puerto Montt, Chile. 82 pp.

Ino, T. & K. Harada. 1961. On the spawning of abalone in the vicinity of Ibaragi prefecture. *Bull. Tokai Reg. Fish Res. Lab*. 31:275–281.

McBride, S. C. 1998. Current status of abalone aquaculture in the Californias. *J. Shellfish Res*. 17:593–600.

Owen, B., J. H. McLean & R. J. Meyer. 1971. Hybridization in eastern Pacific abalones *(Haliotis)*. *Bull. L.A. Co. Mus. Nat. Hist. Sci*. 9:1–37.

Rivera, M. 2001. El Cultivo de Abalón Japonés en Chile. Seminario Taller Análisis y Proyecciones del Cultivo de Abalón en Chile. Diciembre 2001. Puerto Montt, Chile. 82 pp.

Subpesca. 2006. Subsecretaría de Pesca. Resolución final No. 4282. 14 de diciembre del 2005, Valparaíso, Chile.

Sernapesca. 2006. Estadística acuicultura. www.sernapesca.cl

Viviani, C. 1981. Introducción y cultivo experimentales del abalón rojo de California (*Haliotis rufescens*) en Chile. Informe final Proyecto OEA-CIS, U. del Norte, Coquimbo, Chile.

Ziomi, A. 2001. El Cultivo de Abalón Rojo en Chile. Seminario Taller Análisis y Proyecciones del Cultivo de Abalón en Chile. Diciembre 2001. Puerto Montt, Chile. 82 pp.