

MARICULTURE IN SANTA CATARINA: THE PRODUCTIVE CHAIN GENERATED BY THE COORDINATED EFFORT OF RESEARCH, EXTENSION AND TECHNOLOGICAL DEVELOPMENT

Gilberto José Pereira Onofre de Andrade
 Universidade Federal de Santa Catarina
 gilberto.andrade@ufsc.br

Abstract

Currently, the mollusc production chain in Santa Catarina accounts for 98% of all national production. This is an excellent example of how an organized and coordinated work between research and extension institutions can effectively solve real problems and bring up new possibilities for work and job creation. Among the institutions that have been dedicated, in the last three decades, to technological development focused on the needs of this production chain, we can highlight the role of UFSC, as a fundamental link for the creation and maintenance of this activity, through the Marine Molluscs Laboratory, has concentrated on the research and extension related to the production of bivalve molluscs. This paper presents the entire history of the development of the productive chain, as well as the possibilities of future growth of this important economic activity in the state.

Keywords: Bivalve Molluscs. Molluscs Spats. Shellfish Production. Mariculture. Aquaculture.

MARICULTURA EM SANTA CATARINA: A CADEIA PRODUTIVA GERADA PELO ESFORÇO COORDENADO DE PESQUISA, EXTENSÃO E DESENVOLVIMENTO TECNOLÓGICO

Erro! Fonte de referência não encontrada.

Atualmente a cadeia de produção de moluscos em Santa Catarina é responsável por 98% de toda a produção nacional. Este é um excelente exemplo de como um trabalho organizado e coordenado entre instituições de pesquisa e extensão podem efetivamente solucionar problemas reais e criar novas possibilidades de trabalho e geração de empregos. Dentre as instituições que, nas últimas 3 décadas, têm se dedicado ao desenvolvimento tecnológico voltado para as necessidades desta cadeia de produção, pode-se destacar o papel da UFSC, como um elo fundamental para criação e manutenção desta atividade, que, através do Laboratório de Moluscos Marinhos, tem se concentrado na pesquisa e extensão relacionada a produção de moluscos bivalves. Neste trabalho se apresenta o histórico de desenvolvimento da cadeia produtiva, assim como, se traz luz para as possibilidades de crescimento futuro desta importante atividade econômica no estado.

Palavras-chave: Moluscos Bivalves. Sementes de Moluscos. Malacocultura. Maricultura. Aquicultura.

MALACOCULTURA EN SANTA CATARINA: LA CADENA PRODUCTIVA GENERADA POR EL ESFUERZO COORDENADO DE INVESTIGACIÓN, EXTENSIÓN Y DESARROLLO TECNOLÓGICO

Resumen

Actualmente la cadena de producción de moluscos en Santa Catarina es responsable por 98% de toda la producción nacional. Este es un excelente ejemplo de cómo un trabajo organizado y coordinado entre instituciones de investigación y extensión pueden solucionar efectivamente problemas reales y crear nuevas posibilidades de trabajo y creación de empleos. Entre las instituciones que, en las últimas décadas, se han dedicado al desarrollo tecnológico frente a las necesidades de esta cadena de producción, es posible destacar el papel de la UFSC, como un enlace fundamental para la creación y mantención de esta actividad, que, a través del Laboratorio de Moluscos Marinos, se ha concentrado en investigación y extensión relacionada con la producción de moluscos bivalvos. En este trabajo se presenta un histórico de desarrollo de la cadena productiva, de este modo, se trae luz para las posibilidades de crecimiento futuro de esta importante actividad económica en el estado.

Palabras clave: Moluscos Bivalvos. Semillas de Moluscos. Malacocultura. Maricultura. Acuicultura.



INTRODUCTION

As farmers cultivate the land with seeds from various plants towards a rich harvest of food, Santa Catarina in Brazil, also plant seeds in the sea!

Due to the super exploitation of the oceans by the extractive fishing activity, the volume of "production" is in dramatic decline worldwide. Thus, under the current growth of the needs in food production, the sea can not be seen only as an extractive site, but as a fertile field for planting, a whole ocean of possibilities. Aquaculture is one of the last alternatives, not yet saturated, for the increase in food production of high nutritional quality.

The seeds planted in the sea of Santa Catarina in Brazil, are intended for the aquaculture activity called Bivalve Cultivation, specific name given to shellfish farming activity. This is a type of Mariculture that food supply and fertilizer are not needed, which, normally, is one of the major costs of other crops. In this activity, the main bivalves of commercial interest are: mussels (*Perna perna*), the Pacific oyster (*Crassostrea gigas*), the native oyster (*Crassostrea gasar* and *C. rhizophorae*) and scallops (*Nodipecten nodosus*).

Bivalve mollusks are curious animals, it can be said that every animal is a tiny water filtering unit. They have a system to capture the water and make it pass through their gills, which act as a filter and are responsible for breathing, and retention of particles in suspension: phytoplankton, organic and inorganic waste (Huner & Brown, 1985). The retained particles are digested, a portion is absorbed and another eliminated stool shaped. The non-ingested material is removed as pseudo-faeces. Both are reused as input for: aquatic plants, crustaceans, micro-organisms and other animals.

Depending on the species and age, a single adult animal can filter per hour up to 20 liters of water (Quayle & Newkirk 1989). Considering that a standard farm with 1-2 hectares of dimension may have around 40,000 bivalves, it can be said that these are constituted as an army of cleaning, which can filter up to 800.000 liters of water per hour.

Finally, as the bivalves do incorporate the carbon into their shells for long periods, the activity is also seen as a form of carbon retention (WOLF & BEAUMONT, 2011). According to Hinkel (2008) for each of the Pacific oyster shell 100g has absorbed, permanently, 12g of carbon. Thus, providing an additional positive impact and can be characterized as a beneficial type of cultivation to the environment.

Another surprising aspect about the bivalves, concerns the reproductive strategy and its spectacular capacity to generate descendants. The highlight is given precisely the amount of gametes produced by animals ready for reproduction.

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

In natural environment, at the end of the larval stage, individuals will definitely get attached at any type of substrate, usually on the shore rocks. Therefore, during the breeding season, the animals can not get around and try to reproduce. In contrast, to increase the chances that the reproduction occurs, nature ensured them an unusual capacity to produce gametes. Thus, the ability to generate descendants is really spectacular. For example, a single pacific oyster couple can generate 50 million larvae, or even double of that. (HELM & Bourne, 2004). However, being released into the water column, these potential future descendants are at the mercy of luck. At the end, out of the total number of larvae produced, only a small portion should become an oyster.

Considering all the benefits involved in a bivalve cultivation, wherein: the food is plentiful and free in the sea, there is no need to use drugs, causes positive impacts on the environment and, besides that, the animals have a great reproduction capacity; under the perspective of constitute the bases for establish a new production chain, comes up a puzzling question: How would the reproduction productivity under controlled conditions, with low risk of predators or other agents that offer danger to the reproduction process?

This question arose long ago, brought motivation for discussions and was part of the guiding basis for the development of objectives and joint work coordinated between different research and extension institutions. Among all who participated, fit highlight the vital role of the Federal University of Santa Catarina-UFSC and Agricultural Research Corporation and Rural Extension of Santa Catarina- EPAGRI, that worked at multiple challenges over the past 30 years, contributing to the development and strengthening Mariculture in the state. Each party contributed the best possible way in order to research, develop and disseminate the technological basis to enable the creation of a new economic activity in the state.

Given the importance and complexity to the development of a new economic activity, there were many structural aspects discussed, defined, tested and validated. Obtaining young forms was an especially crucial issue, because it should allow a systematic, reliable and continuous supply, to bring security to the production chain, and become the activity attractive. In this sense, it fell to UFSC the search task and development of the technologic package of the whole production, with particular focus on the establishment of the production system of this basic input, the seeds of oysters, mussels and scallops.

It's been over three decades since it all began. Since then there were many attempts, errors, dropouts, persistence and successes to get up the current situation: now the state of Santa Catarina is the national leader in the production of bivalve mollusks and the second largest producer in Latin America, FAO (2016). Based on data from EPAGRI (2016), the production of

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

bivalve mollusks (oysters, mussels and scallops) in Santa Catarina in 2015, generated an estimated financial turnover of R \$ 78,895,697.64 with the direct involvement of 2,315 people and producing a volume of 20,438 tonnes of bivalve mollusks.

Therefore, the creation and development of this activity that had strong economic and environmental impact, occurred as a result of a major coordinated effort of research and extension institutions involved. Notoriously, the UFSC took a decisive role in the viability of the current scenario. In order to understand how it all happened, the next section presents a retrospective of the most important facts till now.

EMERGENCE AND EVOLUTION OF SHELLFISH PRODUCTION CHAIN IN SANTA CATARINA, BRAZIL

The first most consistent experiences of bivalve cultivation in Brazil happened at the beginning of the 70s, with the attempt to cultivate mangrove oyster, *C. rhizophorae* in the states of Bahia, São Paulo and Santa Catarina (POLI, 2004) which, unfortunately, it did not achieve great success. Following the attempts over the decades of 70 and 80, the UFSC in partnership with the ACARPESC (now EPAGRI) gave sequence on work with native oysters in Santa Catarina. However, the results achieved were still insufficient due to the difficulties at that time.

In parallel to this, at this early stage of exploration of the possibilities of bivalves cultivation, in 1974, was the first import and introduction of the species *C. gigas* in Brazil, the Institute of Marine Research, on the coast of Cabo Frio RJ. The following year, in 1975, began research in the Cananéia region, with individuals imported from Japan, by the Fisheries Institute of São Paulo. This species is the productivity champion. It has a large environmental adaptation capacity and also has a higher meat production rates than other species.

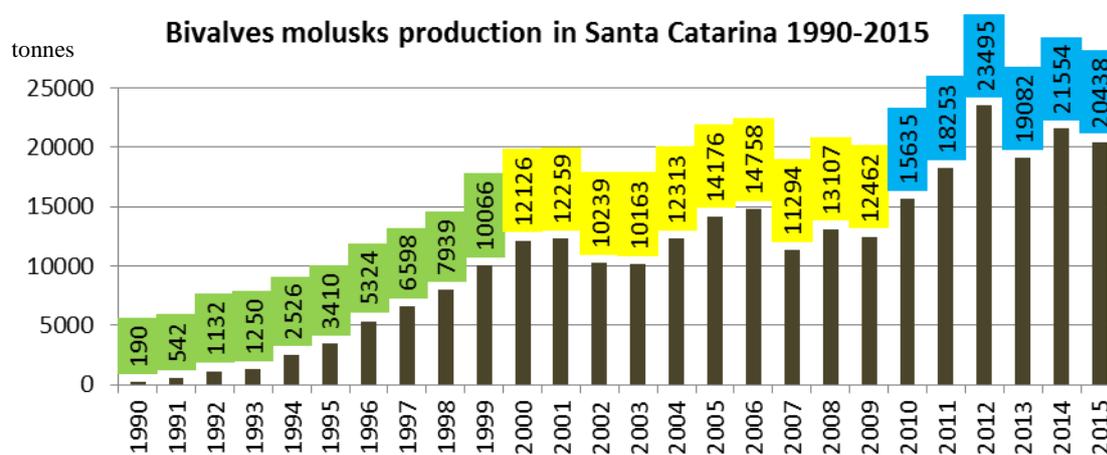
During the 80s, attention naturally turned to this specie, the oyster of the Pacific, as the greatest chance of a successful implementation of oyster cultivation activity in Brazil. Directly aligned with these objectives UFSC, through the Department of Aquaculture, specifically the Marine Mollusks Cultivation Laboratory (LCMM), without losing the focus on native species, also began to direct efforts for research and technological development in order to enable the production of Pacific Oyster in the state. Considering it is an exotic species, unlike native species, it was not possible to obtain seeds directly into the environment. Therefore, came up a major

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

challenge for the Pacific oyster cultivation in Brazil: getting young forms, on a regular basis, towards the production on a commercial scale.

Faced with this challenge the LCMM, in parallel to research with native species, began to work on developing a technological package to enable the production of young forms of this, and other species of mollusks. In 1985 came the "Oyster Project" facing the mangrove oyster cultivation together with shrimps. In 1988 it was created the 1st Mariculture condominium in Brazil, Condomínio de Pesca e Maricultura Baía Norte, which established an important relationship between the local fishermen and researchers at UFSC.

Figure 1: Evolution of the production of bivalve mollusks produced in SC.



Source: EPAGRI (2016)

The 1990s is the beginning of the Mariculture activity on a commercial scale, from the production of oysters, mussels and scallops. In Figure 1, it is clear that this decade was strongly marked precisely by a rapid growth in production volumes, when then production increased from 190 tonnes in 1990, for a total of 10,066 tonnes in 1999. That is an increase of about 5200% in a single decade, which gives an average growth rate of 520% per year. In this decade there was a fact that also deserves to be mentioned, that was the participation of UFSC at STTP (Shellfish Technology Transfer Program) and subsequently at BMLP (Brazilian Mariculture Linkage Program) developed in partnership with CIDA (Canadian International Development Agency). This technical and financial support of Canadians allowed LCMM, in 1995, updated its physical structure to a laboratory able to produce larger amounts of young forms of bivalves. This partnership was not only important in technological infrastructure aspect, but also in the aspect of the skilled labor training. At the end of this period, it could be said that a new activity has turned into reality, with strong impact at the economy and society.

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

In the 2000s the market stopped growing and the demand was stabilized between 11 and 14 tonnes, as shown in Figure 1. It was a period of consolidation and improvement of production processes, but without great growth prospects in the domestic market.

Finally, the actual decade has been marked by a qualification process for the entire production chain and a slight increase in demand. As an example, there is the PLDM (Local Plan for Development of Mariculture) that contributed to regularization of the whole activity, as well as the National Program for Hygienic and Sanitary Control of Bivalves Mollusks (PNCMB), which seeks the adequacy of the chain to the existing requirements in other external markets such as the European Union countries (SOUZA et al., 2014). More recently, in 2016, it was created Law 16,874, which declare the Mariculture as an activity of social and economic interest and establishes the conditions for sustainable development in Santa Catarina.

Figure 2 presents a retrospective of the production chain of mollusks in SC. In general, the 1970s was important for exploration of the possibilities and search for information, it was the period of **investigation**. The next decade, 1980 was the period to undertake further research and identify, in fact, what were the real and feasible opportunities, it was the **development** period. The 1990s was marked by rapid increase of the production volumes, the decade of the **growth**. In the 2000s it can be said that there was a stabilization of demand and consolidation of production processes, the period of the **improvement**. In the 2010s, the focus has been in the organization and regulation of the production chain as a whole. The main goals have been the planning and ordering of all activity aiming to gain more reliability and greater competitiveness. This has been the period of **qualification**.

Figure 2: Retrospective emergence and evolution of the mollusks production chain in SC.

Main facts for each decade					
-Mangrove oyster cultivation at Florianópolis SC (ACARPESC) -Mangrove oyster cultivation at Itaparica BA (UFBA) -1973 The Report "Cananéia Oyster" -1974 First import of <i>C. gigas</i> and introduction at Cabo Frio RJ. -1975 Import of Pacific Oyster from Japan by the Instituto de Pesca in São Paulo.	-1981 Import of Pacific Oyster (UFBA) -1985 "Oyster Project" LCMM/UFSC -1987 Introduction of Pacific Oyster in Santa Catarina -1988 –Aquaculture Master Degree Programa at UFSC -1988 - 1º Mariculture Condominium at Santa Catarina.	-"Aquila Project" 1º comercial cultivation of mussels. -Mapping the cultivations áreas. -1994 Begin of the Mariculture Laboratory at Univali -1995 – STTP Shellfish Tecnology Transfer Program. & Brazilian Mariculture Linkage Program – no LCMM – UFSC.	-2002 CIDA's Award of Excelence - LCMM -2004 Expansion of LCMM structure. -2004 Increased the production capacity of seeds and adults. -2005 Award FINEP Technological Innovation LCMM/UFSC -2007Aquaculture Ministry was created -2008 Red tides and enviroment problems. -2009 Code of conduct for sustainable development and responsible of the shellfish cultivation in Brasil.	-2011 PLDM: Local Plan for Development of Mariculture -2011 Bidding and demarcation of cultivation areas -2012 PNCMB: National Program for Hygienic and Sanitary Control of Bivalves Mollusks -2016_ Law 16.874 about the activity of Mariculture in Santa Catarina	Prospects: - Increased the number of cultivation areas. - Investments in tools and machines for production. -Mechanization of production processes. - Processes and Products Certification. - Exportation of Brazilian Bivalves. - Free trade agreements between countries.
Decade 1970 INVESTIGATION	Decade 1980 DEVELOPMENT	Decade 1990 GROWTH	Decade 2000 IMPROVEMENT	Decade 2010 QUALIFICATION	Decade 2020 EXPORTATION
-Search for economic	-Research and	-Problems correction.	-Processes	- Organization and	Prospects:

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

alternatives. -Opportunities prospection - Collection of information.	Technological development. -Native species cultivation -Search for feasible opportunities -Definition of the technological bases. - Search for new species of mollusks for cultivation.	-Processes consolidation. -Development of production tools. -Suppliers development. - Strong growth.	improvement. -Increase of capacity. -Technological dissemination. - Production stabilization. -Awareness of the potential for export.	control in the Productio stages of the Chain. -Regularizatio of the Mariculture Industry -Processes qualification for export.	-Continuous improvement of the production processes. -Innovation in machines and tools for production. -Certification process for products and companies. -Business contact with foreign Market.
Main goals for each decade					

In the development of Production Chain of Mollusks, the success of coordinated work, of research and extension, at the institutions involved has granted to the state of Santa Catarina the isolated position of leader of this type of market in Brazil, with about 98% of all national production (IBGE 2015). Florianópolis has become recognized as the "Oyster Capital" and this is so true that the main event in town - National Oyster Festival and Azorean Culture - Fenaostra is already in its 17th edition in 2016. An event that attracts thousands of participants each year and, besides this, it increases the recognition of Florianópolis as a center of production excellence of mollusks, throughout Brazil and even on abroad.

DIAGNOSTIC OF PRODUCTION CHAIN OF MOLLUSKS AT SANTA CATARINA

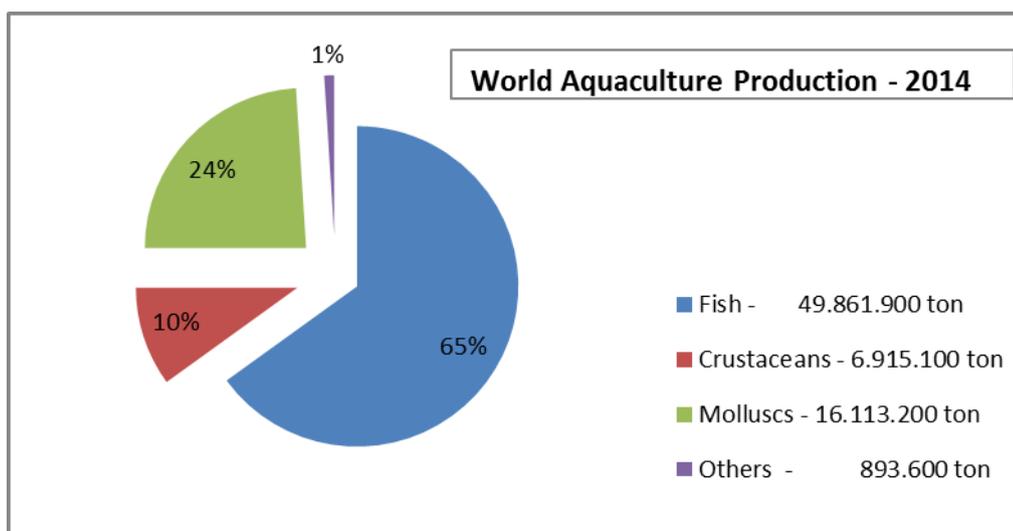
Brazil is already a main player in the production and export of different types of animal protein, such as beef, with the second largest herd in the world and 1st position in exports. Similarly, there is the poultry industry, where the country leads the world ranking of export of chicken meat, with around 40% of world trade and occupies 3rd place at production volume. Just behind there is the pork's production, where the country occupies the 4th position both in production as in export volume. It is evident, then, that the country has tradition and occupies a prominent place in the production and export of animal protein in the world. It should be mentioned the outstanding participation of the Santa Catarina state in the production of pork and poultry.

In what regards the production and export of fish, whether in continental aquaculture or Mariculture, the country has not yet submitted a consistent performance with its aquaculture production potential. The trade balance of fish has been historically deficit. The current production of both, fisheries and aquaculture, has not been sufficient to meet the domestic demand of the country, consequently incurs on a larger volumes of recurring imports.

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

From the point of view of the global production of fisheries, that is for human consumption and coming from cultivation, the group of mollusks ranks 2nd in the volume of world production, with 24% of all production, equivalent to an amount of 16,113,200 tonnes , according to the figure 3 (FAO, 2016).

Figure 3: Aquaculture production in 2014 (not included aquatic plants).



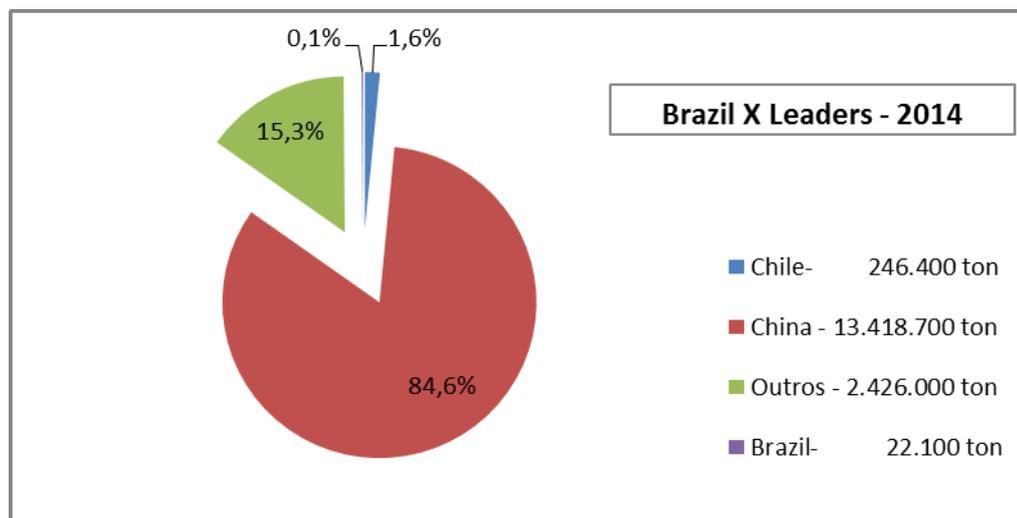
Source: FAO, 2016

There is no doubt the importance of the results achieved with the Mariculture in Santa Catarina, especially for people and companies directly involved in mollusks production activity. Recalling that the Santa Catarina mollusks production represents about 98% of production of bivalve in Brazil, despite this national outstanding performance when it assumes the global perspective, it is possible to realize that there is still much to be explored.

In Figure 4, it is considered only the group of mollusks for evaluation, specifically to grab attention to the comparison between Brazil and the world leader, China, with 83% of all global production, and the leader in Latin America, Chile, with the production of 246,400 tonnes. The current production in Brazil is around 22,100 tonnes or equivalent to 9% of production from neighboring Chile, and only 0.14% of world production.

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

Figure 4: Global production of mollusks China, Chile, Brazil and others.



Source: FAO, 2016

China takes the leading position isolated in the world ranking, with production more than four times the total production throughout the world, and therefore is very distant from the national reality.

However, Chile can be an interesting reference due to its organized growth. In 1990, it had a production of 3,800 tonnes of bivalves. With an accurate strategic vision, combined with a hard work for the opening of some European markets, production reached 24,100 tonnes in 1997. From this point on volumes grew rapidly, in 2003 have reached 77,700 tonnes, and in 2014 reached 246,400 tonnes. It is a country with export culture, with free trade agreements and open export channels, embarking their fisheries to several countries, including Brazil. For example, in 2011, Chile exported 58,049 tonnes of mollusks just for the European Union, shared between the following countries: Spain 42%, France 20.8%, UK 5.8% and Netherlands 4.4%. (Sernapesca, 2011).

On the sidelines of a possible opening of the market for the sale of the Brazilian bivalve abroad, it is presented a brief analysis of the current state of the mollusks cultivation at Santa Catarina in Brazil.

The analysis of the internal environment (Santa Catarina and Brazil), we have:

➤ STRONG POINTS

- ✓ Production chain already established and operating continuously for more than 20 years.
- ✓ The current production areas already tendered are still far from exhausting the capacity. In 2014, there was still 70% of available capacity (EPAGRI, 2015).

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

- ✓ Santa Catarina coastline is extensive, with environmental and geographical conditions favorable for expansion of production areas.
- ✓ Recognition of excellence and state tradition as a producer of high quality shellfish.
- ✓ The species produced today have excellent growth performance in the Santa Catarina environment. The Pacific oysters have very rapid growth, it can reach the commercial size in 8 months (MANZONI, 2001). In France, to reach the same commercial size it can take from 2 to 4 years (Gosling, 2004).
- ✓ Implementation of sanitary control programs (PNCMB) in 2012, as well as the code of conduct with the use of best production practices.
- ✓ Development of techniques for maturing breeding in laboratory and remote larval settlement.
- ✓ Applied research in genetic improvement at bivalve cultivation to improve the performance of the animals.

➤ WEAKNESSES

- ✓ Artisanal production method, without intensive mechanization, as a result it has a relatively low productivity in harvest of crops.
- ✓ Difficulties in expanding the domestic demand due to, among other factors, cultural issues (eating habits) and therefore very hard to be changed.
- ✓ Very low product diversification.
- ✓ Size of the areas of the current fish farms is on average small, up to 2 hectares. Since for the use of mechanized cultivation model, the areas with 10 hectares, or more, are more suitable.
- ✓ Because of favorable factors in Santa Catarina (sheltered areas, temperature, nutrients and salinity) has large primary production in the ocean, which in turn also favors the spread of competing organisms (biofouling) with mollusks, which turns the cleaning process a frequent activity in the field.
- ✓ Production activity is not ergonomic and potentially harmful to workers' health.
- ✓ The production and supply of young forms (seeds) of bivalves are concentrated in a few suppliers.
- ✓ Low investment in public sanitation, which can impact at the water quality.

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

The analysis of the external environment (external market), we have:

➤ OPPORTUNITIES

- ✓ The adaptation of national standards of production and sanitary control to requirements already applied at other countries that are major producers and consumers (Jacomel, 2014; Souza et al, 2014.).
- ✓ Exhaustion of available areas for shellfish cultivation at other countries, considered major producers and consumers, as it is the case of France and Spain (VARADI et al., 2001).
- ✓ Technological packages, geared to intensive mechanization, already developed and fully operating in other countries.
- ✓ Standardization of best cultivation practices and dissemination of these globally.
- ✓ The Mollusks world market moves about US \$ 19 billion per year (FAO, 2016).

➤ THREATS

- ✓ New diseases and pathogens that have caused mass mortality in shellfish cultivation farms in Europe (RENAUT., 1996; SABRY et al, 2009).
- ✓ Issues bigger order, such as the possibility of ocean acidification, from the environmental degradation around the world, can seriously harm the shellfish cultivation (TURLEY & GATTUSO, 2012).
- ✓ Entry and growth of the Chilean fisheries imports to the Brazilian market.
- ✓ Increased contamination of oceans due to domestic and industrial pollution.
- ✓ The bigger the pollution, the bigger the probability of "red tides" more frequent.
- ✓ The emergence and dissemination of new parasites that attack the mollusks.

Based on the information presented in this analysis, if we consider the exportation potential, it is possible to imagine that the next decade can be extremely promising for the Production Chain of Mollusks in Santa Catarina. Indeed, the export of the products generated here can mean a major economic and social revolution. In this way, the result may be a radical growth in production volumes, even higher than the growth that has already been experienced in the 90s, providing sizeable increases in financial activity and job creation.

Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

However, it is known that, to be able to export there is a long road to be traveled before. This path has been and still will be travelled, constantly evolving. The high degree of competitiveness of countries participating of the international trade in shellfish requires major changes in the national production chain, such as: strategic planning oriented for export, create greater business intelligence, adapting products to target markets, increase product diversification, increase production capacity both in size and at the technological improvement, process improvement, expansion of mechanization, organization management, define strategies for dissemination and trade promotion, establish free trade agreements, logistics structure improvement and finally sell abroad.

In view of the exemplary performance of Chile, that through an organized and coordinated work between public entities, shellfish producers and research and extension institutions. It is believed that Santa Catarina has got all the elements necessary to initiate a new era in the state, with modernization of the field and a new orientation to the production, geared to meet, besides the domestic market, the huge global market of bivalve molluscs.

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Mariculture in Santa Catarina: the productive chain generated by the coordinated effort of research, extension and technological development

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