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ECONOMIC ANALYSIS OF SCALLOP CULTURE AT THE NORTH COAST OF SÃO PAULO STATE, BRAZIL

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[a]1 US$ = R$ 3.12, values of July 2017

ABSTRACT

The aim of this study was to analyze economically the production of scallops *Nodipecten nodosus* at the north coast of São Paulo State, from a hypothetical cultured area of 0.2 ha. We used a final density of 16 scallops floor^{-1} of Japanese lanterns and considered a survival rate of 68.85% and 81.22% at the final cycle of nine months. In these conditions, the intern rate of return (IRR) ranged from 40.58% a 103.99%, based in commercial selling prices of R$ 39.50 and R$ 49.50[a] per dozen for the two survival rates. The total production cost (TPC) per dozen of scallops varied from R$ 24.27 to R$ 28.63, lower than the considered selling prices. The highest net present value (NPV) obtained was R$ 989,376.35 for the selling price of R$ 49.50 and survival of 81.22% and the lowest NPV was R$ 288,209.84 for the selling price of R$ 39.50 and survival of 68.85%. These results show the economic viability of the scallop's culture, fact that may promote the development and expansion of this activity in north coast of São Paulo State.

Key words: production costs; investment; pectiniculture; mariculture; profitability.

ANÁLISE ECONÔMICA DO CULTIVO DE VIEIRAS NO LITORAL NORTE DO ESTADO DE SÃO PAULO, BRASIL

RESUMO

O objetivo deste estudo foi analisar economicamente o cultivo da vieira *Nodipecten nodosus,* no litoral norte paulista a partir de um cultivo hipotético em uma área de 0,2 ha. Utilizou-se a densidade final de 16 vieiras piso^{-1} de lanterna e a taxa de sobrevivência considerada, ao final do ciclo de nove meses, variou de 68,85% a 81,22%. Verificou-se que a taxa interna de retorno (TIR) variou de 40,58 a 103,99%, a partir dos preços base para a comercialização de R$ 39,50 e R$ 49,50* a dúzia, nas duas taxas de sobrevivência estudadas. O custo total de produção (CTP) por dúzia de vieira variou de R$ 24,27 a R$ 28,63, sendo inferior aos preços de comercialização considerados. O maior valor presente líquido (VPL) obtido foi de R$ 989.376,35 para o preço de venda de R$ 49,50 e sobrevivência de 81,22%, e o menor de R$ 288.209,84 para o preço de venda de R$ 39,50, na menor sobrevivência (68,85%). Os resultados comprovam que o cultivo de vieiras apresenta viabilidade econômica, fato que pode estimular o desenvolvimento e expansão dessa atividade no litoral norte do Estado de São Paulo.

Palavras-chave: custo de produção; investimento; pectinicultura; maricultura; rentabilidade.

INTRODUÇÃO

The scallops are the bivalve mollusks cultured for human consumption with highest commercial value (ARELLANO-MARTINEZ *et al*., 2011). World production increased from 1,411 t in 2008 to 1,922 t in 2014 (36.2%), with selling price of US$ 1,740 per ton, representing a total production value of US$ 3.32 billion (FAO, 2016).

Among the representatives of the Pectinidae family in Brazil, the species with the highest culture potential is *Nodipecten nodosus*, that reaches 120 to 150 mm in length (ABELIN *et al*., 2016). This species is found in sandy bottoms with consolidated substrates between 5 and 25 m deep. It is distributed from the coast of Florida (USA), to Santa Catarina (Brazil) (LODEIROS *et al*., 1998). Due to its high commercial value and fast growing, this species has been largely studied in Brazil (RUPP, 2016). Other factors favorable to its cultivation are the adaptability to various environmental

conditions, ease of obtaining seed in hatcheries, excellent taste and the acceptability by consumers (OSUNA-GARCIA *et al*., 2008).

Currently, there are small-scale commercial scallop farms in the States of Santa Catarina, Rio de Janeiro and São Paulo (RUPP, 2016). Santa Catarina is the largest producer, with a production of 37.2 tons of *Nodipecten nodosus* species in 2015 (SANTOS and COSTA, 2016) All juveniles (seeds) used in these cultures come from hatcheries. Only two hatcheries, situated in Rio de Janeiro and Santa Catarina, supply seeds on a commercial scale. Larviculture phase are based on well-defined protocols, starting with obtaining of fertilized eggs from broodstock scallops collected from the wild.

Despite of the large potential for scallop farming expansion, there is little information on its economic feasibility in Brazil. GIUSTINA *et al*. (2013) carried out an economic analysis based on technical information and practices used by producers from Penha (Santa Catarina). MOSCHEN (2007) studied the economics of three systems of mussels and scallops cultivation at Rio de Janeiro coast. However, there is no economic studies of scallop culture in the state of São Paulo. According to GIUSTINA *et al*. (2013), an economic analysis helps to define management strategies and determine the key parameters that affect a company's budget.

Thus, this work aims to perform an economic analysis on the cultivation of *Nodipecten nodosus* scallops on the north coast of the State of São Paulo, in order to present a commercial vision of this activity to technicians, producers and other stake holds of the production chain and assist them in the decision-making process of initiate or promote the culture of this bivalve in that region.

METHODS

Culture techniques

Scallops cultivation occurs in Brazil since the years 1990, when hatchery technology was developed in Santa Catarina state (RUPP and PARSONS, 2004). The growing phase at sea, which starts with the transference of the juveniles (seeds) from hatcheries to the culture structures, began to be studied in early 2000 decade, also in Santa Catarina (ALBUQUERQUE and FERREIRA, 2006; RUPP, 2007) and São Paulo States (MARQUES *et al*., 2004; BUENO *et al*., 2010).

Only the economic analysis of the growing phase at sea is presented in this study, considering that this phase involves a larger number of producers than the hatchery one. A hypothetical model of cultivation located in the north coast of the State of São Paulo, a region that presents favorable environmental conditions for the cultivation of *Nodipecten nodosus* (BUENO *et al*., 2010), as well as a favorable logistic situation, between the cities of São Paulo and Rio de Janeiro, two of the largest Brazilian seafood consuming centers. The techniques adopted in this study followed those used in commercial farms at the northern coast of São Paul, in research experiments conducted by the Fishery Institute, SAA, SP in Caraguatatuba and Ubatuba (SP) and by Santa Catarina producers (RUPP, 2007).

In scallop's growing phase, the producers acquire seed (juveniles from 10 to 20 mm high) from three Brazilian hatcheries currently actives, located in Santa Catarina and Rio de Janeiro States. Other hatcheries in Brazil can also produce scallop seed, but their production is intermittent, mainly due to the low demand. The active hatcheries also work according to the demand, but are able to increase production if necessary. On the other hand, it is believed that, with the increase in the number of producers, the number of private hatcheries also tends to grow up.

The most commonly structures used in the growing phase are the long lines (Figure 1), which are floating lines composed of a main cable, usually 50 m long, attached by its ends to anchors by mean of anchoring cables. Long-lines are used for culturing different species of mollusks, such as mussels, oysters and scallops.

In the specific case of scallops, the mollusks are placed inside structures called "Japanese lanterns" (Figure 2), composed of 5 to 10 circles of meshed plastic, each 40-50 cm in diameter, called "floors", which are involved by polypropylene mesh of 4 to 15 mm, and kept at a distance of 20 cm from each other, forming an assembly with 1 to 2 m in height. At the upper end of this assembly is attached a polyethylene cable of 5 to 8 mm in diameter that ties the lantern to the main cable of the long lines. The recommended spacing between the lanterns is about 80 cm, in order to avoid lantern shocks and to allow good water circulation, favoring the transport of oxygen and diluting scallops

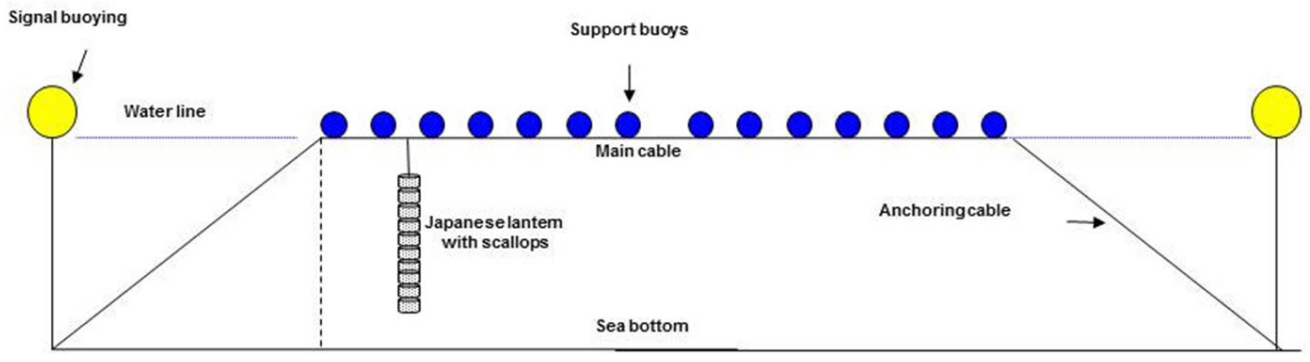

Figure 1. Drawn, without scale, of a long-line (drawn by the authors).

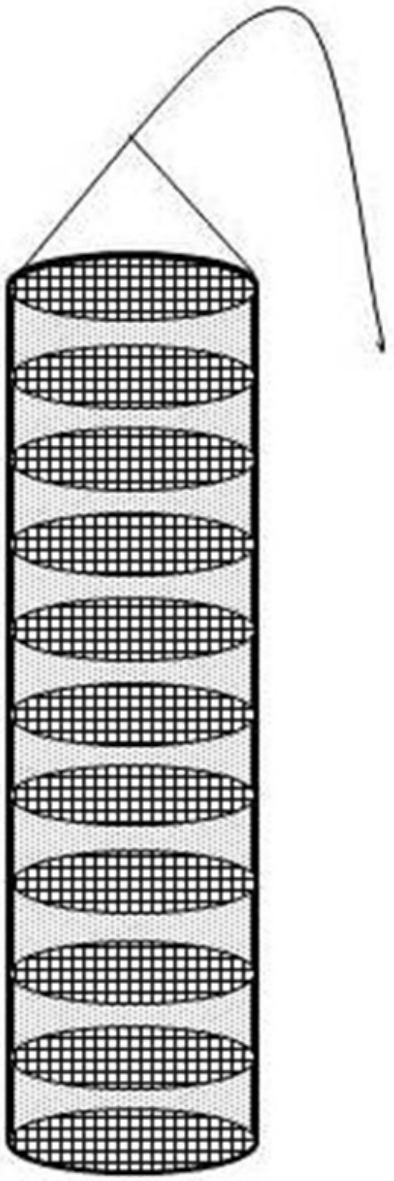

Figure 2. Drawn, without scale, of a Japanese lantern with ten floors (drawn by the authors).

excreta. The spacing between the long lines is at least 5 m, and it is also determined by the local sea agitation.

There are two kinds of Japanese lanterns used according to the three phases of scallop culture in Brazil. The first, or "nursery phase", lasts three months and is held in lanterns with floors 40 cm in diameter and mesh of 4 mm (nursery lanterns), in which scallop seed are stocked at a density of 200 per floor, until they reach 30 mm in height. The lanterns used in the next two phases have floors with 50 cm in diameter and mesh of 15 to 20 mm, being called "growing lanterns". In the second phase or "intermediate phase", the density used is 80 per floor and scallops are reared by also three months, till reach 50 mm in height. Finally, at the third phase, or "growing phase", densities are reduced to 16 per floor and scallops are reared for more three months, until reach 65 mm in height, resulting in a total culture time of 9 months.

Scallops are seawater-filtering mollusks, feeding primarily on phytoplankton and particulate organic matter in suspension, thus dispensing the supply of supplementary feed. The main item of culture management is the monthly cleaning of the fouling adhering to the lanterns, by means of salt water blasting, which, for greater practicality and economy of labor, is done on a raft anchored next to the long-lines. According to RUPP (2007), for the process not to become uneconomical, the cleaning of fouling from scallop shells should only be done every 120 days, and also at the harvest, before the scallops' sale. During the cleaning of shells, scallops should remain submerged in seawater inside large polyethylene boxes, and the valves must be cleaned with hard brushes, taking care not to damage them. In this work, it was considered that shell cleaning was done at the end of each one of the phases of cultivation and at harvest.

After be harvested and cleaned, the scallops are removed from the water and the shells are immediately involved with rubber elastics so that they remain closed during transport, in order to keep the seawater oxygenated inside and thus increasing the survival time out of water (ABELIN *et al*., 2016). Scallops are disposed in Styrofoam trays (one dozen per tray), packed in stackable plastic mesh boxes and transported in an air-conditioned vehicle, usually type van, at a temperature of 20 °C, till the destination.

Commercialization

Due to the proximity of the production site to the consumer centers, the commercialization is done directly with the final consumers, which can be hotels, restaurants and bistros of São Paulo, Santos and neighbor cities, or even the general public. In the case of smaller producers, most of the production is sold "at the farm gate," at prices ranging from $ 39.50 to $ 49.50 per dozen, depending on the size of the scallop. The selling price of $ 49.50 is reached by animals larger than 65 mm in height. Prices paid by commercial establishments reach approximately the same value, but in this case, the product usually is delivered directly to the buyer. The analysis considered delivery within a maximum radius of 250 km from the production site, which corresponds to the metropolitan regions of São Paulo State, Santos and Vale do Paraíba.

Main zootechnical indicators considered

For the economic analysis, an aquaculture area of 0.2 ha was considered as the production unit, corresponding to the maximum size permitted by the Law of the Economic Ecological Zoning of the north coast of SP (Decree 49.215/04), which is currently in effect. In each production unit, seven long lines with 50 m in length can be disposed, each of them with capacity for 62 lanterns with 10 floors, totaling a total capacity of 434 lanterns per aquaculture area.

The main zootechnical indicators considered in this analysis and related in Table 1 as production factors, were based on data of RUPP (2007, 2016) for Santa Catarina farmers and in experiments

Table 1. Factors of production for *Nodipecten nodosus* scallop farming in 0.2 ha, July, 2017.

Factor	Unity	Condition A	Condition B
Production cycle	month	9	9
Production cycles.year^{-1}	n	1.33	1.33
Number of seed.cycle^{-1}	thousands	80	80
Number of seed.year^{-1}	thousands	106.4	106.4
Initial density nursery phase	seed.lantern^{-1}	2,000	2,000
Initial density intermediate phase	seed.lantern^{-1}	800	800
Initial density growing phase	seed.lantern^{-1}	160	160
Nursery lanterns	n	40	40
Intermediate lanterns	n	90	90
Growing lanterns	n	428	428
Survival rate – Nursery phase	%	90	85
Survival rate - Intermediate phase	%	95	90
Survival rate – Growing phase	%	95	90
Total survival rate	%	81.22	68.85
Final scallop number (above 65 mm high)	dozen.cycle^{-1}	5,144	4,361
Final scallop number (above 65 mm high)	dozen.year^{-1}	6,841	5,799
Final scallop number (below 65 mm high)	dozen.cycle^{-1}	271	230
Final scallop number (below 65 mm high)	dozen.year^{-1}	360	305

Source: Research data.

carried out in Ubatuba (SP) by MARQUES *et al*. (2004) and BUENO *et al*. (2010). It was considered the accomplishment of 1.33 cycles per year, because as there is no seasonality in the production, the cultivation can be done in a staggered way, by means of seeding 48 or 49 lanterns per month, in order to completely fill the long lines in nine months. This enables the constant maintenance of the long-lines and lanterns, avoiding a complete stoppage of the cultivation only for this purpose. The main production factors for scallop cultivation are presented according two mean survival conditions, 81.22% (Condition A) and 68.85% (Condition B).

In order to manage the cultivation, the owner of the enterprise was considered a permanent employee, which is also in charge of administrative services, accounting, equipment and supplies purchase, marketing and product delivery, as well as an additional permanent employee, both receiving monthly a minimum salary in effect in Brazil.

As temporary labor, occasional employee services (R$ 78.00 man.day^{-1}) were contracted for the most intense service periods, such as assembly and installation of long lines, scallop seeding, culture management, cleaning of the lanterns and scallops and harvest. For a production cycle (9 months) this expense was calculated at R$ 15,300.00.

Production costs

The cost structure considered in the economic analysis was:

a) Effective Operational Costs (EOC), which includes expenses for: ranch and air conditioned van rental, permanent and temporary labor, boat and van fuel and purchase of seed, equipment and other materials;

b) Total Operational Cost (TOC), which includes the sum of the EOC plus social labor charges (contribution to the social security, vacation and other expenses), that corresponds to 40% of the labor cost (HENRIQUES *et al*., 2010); financial charges (annual interest rate over half the EOC in the production cycle) and boat, tools and equipment depreciation;

c) Total Production Cost (TPC) which is the sum of the TOC plus the annual interests of the capital related to the investment.

Return on investment and profitability indicators

For the economic analysis, it was considered a ten-year exploration time horizon, with investment fully applied in year zero.

The viability of the investment was assessed from indicators such as the Internal Rate of Return (IRR), which takes into account the capital variation over time. When evaluating a project by IRR, it is found that it is only economically feasible when the rate is higher than a certain attractiveness rate. The minimum attractiveness rate considered in this study was 10.25% equivalent to the annual interest that could be received in financial investments based on the Brazilian SELIC Rate, determined by the Brazilian Monetary Policy Committee (COPOM), higher than those available in government-subsidized bank loans aimed at this type of activity, classified as rural credit (PROGER, PRONAF, etc.).

Besides IRR, other indicators of economic viability were used: the Payback Period (PP), defined as the number of years necessary for recovering the initial capital invested; and the Net Present Value (NPV), which is the current value of the series of future

revenues for a period, discounting the interest rate subtracted from the net investment (NOVAES *et al*., 2012).

Another cost indicator considered was the Breakeven Point (BP), which determines the minimum production necessary to cover the cost, according to the selling price of a dozen scallops (Pdz), and given by the formula: $BP = TOC \cdot Pdz^{-1}$

Other indicators of profitability evaluation adopted in the present study are described in MARTIN *et al*. (1998):

a) Gross Income (GI): Production of scallops in dozen, multiplied by the selling price of the dozen scallops on the market.

b) Operating Profit (OP): Difference between GI and TOC. This indicator measures short-term profitability, showing the financial and operating conditions of the activity. Thus, we have: OP = GI - TOC

c) Gross Margin (GM): Margin over TOC, that is, result obtained after the producer bears the operating cost, considering the Income Gross of the activity. Formalizing, we have: GM = (GI - TOC) / TOC × 100

d) Profitability Index (PI): Relationship between OP and GI, in percentage. This indicator shows the available rate of revenue from the cultivation of scallops after payment of all operational costs involved. Then: PI = (OP / GI) × 100.

e) Cash Flow (CF): Algebraic sum of the inputs (GI) and expenses incurred during the activity cycle (TOC). This instrument makes it possible to identify a net financial flow at each year, used for the calculation of IRR, PP and NPV. According to MARTIN *et al*. (1994), it shows the cash situation of the activity and is the result used to cover other fixed costs, risks, return on capital and managerial capacity of the business.

To calculate CF, we considered the expenses related to the initial investment in the first year, considered as zero year, because it has a very variable dimension, considering that it would take 12 months to implement completely the project; and the Effective Operating Cost plus the financial and social labor charges and annual interest on the capital relating to the investment. Estimates were made based on two selling prices per dozen scallops (R$ 39.50 and R$ 49.50), commonly used by scallop producers in the north coast of São Paulo. The taxation of this product varies according to the State of the Federation; in this study we considered 18% of ICMS currently in effect in the State of São Paulo and 2.7% of FUNRURAL, which was charged to the sale in the rural producer's note.

RESULTS

Investments

The investments required to the implementation of scallop cultivation, including the acquisition of equipment, a vessel, as well as labor for the assembly and anchorage of long lines, was of R$ 185,730.63 (Table 2). Items with a useful life of less than 10 years were incorporated as expenses in the respective years of replacement.

Operational and production costs

The estimated Total annual Production Cost (TPC) for scallop cultivation was of R$ 174,742.85 (Table 3), which can be considered high, since represents approximately 94% of investments value (Table 2), thus demonstrating the high cost

Table 2. Investments required to the implementation of *Nodipecten nodosus* scallop cultivation in 0.2 ha, at North coast of Sao Paulo state. R$ 1.00 = US$ 0.32, values of July 2017.

Item	Quantity	Total value	Life cycle	Annual Depreciation	Annual capital	Total
		R$	(replacement)[1]	(a)	interest [2] (b)	(a)+(b)
Support raft (32 m^2)	1	40,000.00	20	2,000.00	2,400.00	4,400.00
Long-lines (cables + buoys + anchors)	7	17,500.00	10	1,750.00	1,050.00	2,800.00
Nursery lanterns	40	10,400.00	5(1)	5,200.00	624.00	5,824.00
Growing lanterns	428	79,180.00	5(1)	15,836.00	4,750.80	20,586.80
Labor for long-lines assembly and anchorage	27 md[(3)]	2,106.00			252.72	252.72
Boat with 6 m in length	1	5,235.00	20	261.75	314.10	575.85
Outboard motor (15 HP)	1	8,000.00	10	800.00	480.00	1,280.00
Motor pump for salt water	1	6,000.00	2(5)	3,000.00	360.00	3,360.00
Pressure washer (2.200 psi)	1	7,500.00	10	750.00	450.00	1,200.00
Plastic boxes (60 L) for storage of live scallops	50	2,250.00	10	225.00	135.00	360.00
Plastic buckets (20 L)	20	600.00	5(1)	120.00	36.00	156.00
Diverse tool kit	1	800.00	5(1)	160.00	48.00	208.00
Stackable plastic mesh boxes for scallops transport	50	750.00	5(1)	150.00	45.00	195.00
Project design (3% of total value)	1	5,409.63			649.16	649.16
Total		**185,730.63**	**-**	**30,252.75**	**11,594.78**	**41,847.53**

[1]Useful life in years and number of replacements in parentheses. [2]Interest rate of 6% per year on the venture capital. [3]Man-day. Source: Data of research.

Table 3. Operational Cost (Effective - EOC and Total - TOC) and Total Production Cost (TPC) per cycle and per year[1] for *Nodipecten nodosus* culture in 0.2 ha, North coast of São Paulo State. R$ 1.00 = US$ 0.32, values of July 2017.

Item	EOC	Social Charges [1]	Financial Charges [2]	TOC	Other fixed costs	TPC
Boat and equipment ranch rental	13,500.00		1,620.00	15,120.00		15,120.00
Permanent labor	16,866.00	6,746.40	2,833.49	26,445.89		26,445.89
Temporary labor	15,300.00	6,120.00	2,570.40	23,990.40		23,990.40
Boat fuel	4,860.00		583.20	5,443.20		5,443.20
Scallop seed purchase	16,000.00		1,920.00	17,920.00		17,920.00
Diverse material for cleaning and maintenance	200.00		24.00	224.00		224.00
Equipment for individual safety	5,000.00		600.00	5,600.00		5,600.00
Rubber elastics for closing scallops	350.00		42.00	392.00		392.00
Styrofoam trays for transport	550.00		66.00	616.00		616.00
Air-conditioned van rental	2,000.00		240.00	2,240.00		2,240.00
Van fuel	1,500.00		180.00	1,680.00		1,680.00
Depreciation of boat, equipment and tools [3]				22,689.56		22,689.56
Annual interests on invested capital					8,696.09	8,696.09
Total cycle^{-1}	76,126.00			122,361.05		131,057.14
Total year^{-1}	**101,501.33**			**163,148.07**		**174,742.85**

[1]Social charges = 40% of outflows. [2]Financial charges = 24% a.a. on half of EOC added to social charges. [3]Depreciation estimated according to the useful life. Source: Data of research.

value for the operation of the activity. It was also observed that the Total annual Operational Cost (TOC) was of R$ 163,148.07 (Table 3). This value was used as an expense in the calculation of cash flow (MARTIN *et al*., 1994).

Rental and fuel expenses were considered for an air-conditioned van, essential for commercial contacts and small deliveries, totaling R$ 3,500.00 for each scallop production cycle (Table 3).

Internal rate of return and period of capital recovery

The selling prices of scallops, proposed in this study (R$ 39.50 and R$ 49.50 per dozen), are equivalent to those practiced in the market of São Paulo and Rio de Janeiro. Table 4 shows that all the production costs obtained (EOC, TOC and TPC) of the cultivation of scallops in the two studied conditions (A and B) are lower than the usual commercialization prices.

A large variation of the Internal Rate of Return (IRR) (40.58% to 103.99%) and the Profitability Index (PI) (32.33% to 54.23%) was observed for the 10-year horizon; however, both were much higher than the attractive annual rate stipulated in 10.25% (Table 5).

The Breakeven Point (BP) evidenced the viability of *Nodipecten nodosus* culture in the two proposed survival conditions, since it is below the production considered in the worst case scenario. The Payback Period (PP) in the worst case scenario is 2.38 years, considered as being of a low risk, providing a greater chance of success and a quick return on invested capital.

Table 4. Production costs of a dozen of *Nodipecten nodosus* cultured in 0.2 ha, North coast of São Paulo State. R$ 1.00 = US$ 0.32, values of July 2017.

Cost (R$.dz^{-1})	Condition A	Condition B
EOC	14.10	16.63
TOC	22.66	26.73
CTP	24.27	28.63

It was found that the best Net Present Value (NPV), with a rate of 10.25%, was of R$ 989,376.35 for the selling price of R$ 49.50, (Condition A), and the lowest of R$ 288,209.84 for the selling price of R$ 39.50 (Condition B) (Table 5)

Considering an unfavorable scenario of total loss of annual production, which could occur due to climatic disasters such as severe hangovers due to the entry of cold fronts and meteorological tides accompanied by strong winds. In this scenario, applying the IRR to the attractiveness ratio (10.25%) for the worst survival conditions and marketing price, the value obtained was 31.28%, still favorable to the maintenance of the activity (Table 6). In a sensitivity analysis, in the worst condition, the IRR becomes positive from the selling price of R$ 29.80, and from R$ 31.72 above the attractive rate of 10.25% (Figure 3).

Table 5. Analysis of costs and investment profitability of *Nodipecten nodosus* culture in 0.2 ha, in the north coast of the State of São Paulo. R$ 1.00 = US$ 0.32, values of July 2017.

Cash Flow	Condition A		Condition B	
Selling price (R$ dz^{-1})	49.50	39.50	49.50	39.50
Gross Income (R$ ano $^{-1}$)	356,450.00	284,440.00	302,150.00	241,110.00
Operating Profit (R$ ano $^{-1}$)	193,301.93	121,291.93	139,001.93	77,961.93
Gross Margin (%)	118.48	74.34	85.20	47.79
Profitability Index (%)	54.23	42.64	46.00	32.33
Internal Rate of Return	103.99%	64.87%	74.56%	40.58%
Net Present Value (10.25%)	989,376.35	551,618.42	659,279.76	288,209.84
Net Present Value (20%)	624,682.32	322,782.40	397,031.08	141,122.59
Payback Period (years)	0.96	1.31	1.50	2.38
Breakeven Point (dozen)	3,262.96	4,078.70	3,262.96	4,078.70

Source: Research data.

Table 6. Results of the economic indicators: Internal Rate of Return (IRR) and Net Present Value (NPV), simulating a crop loss. R$ 1.00 = US$ 0.32, values of July 2017.

Indicators	Condition A		Condition B	
IRR (%)	101.04	59.10	69.72	31.28
NPV 10.25% (R$)	790,891.65	393,231.58	491,031.33	153,950.77
NPV 20.00% (R$)	505,307.93	227,524.02	295,841.66	60,375.33

Source: Research data

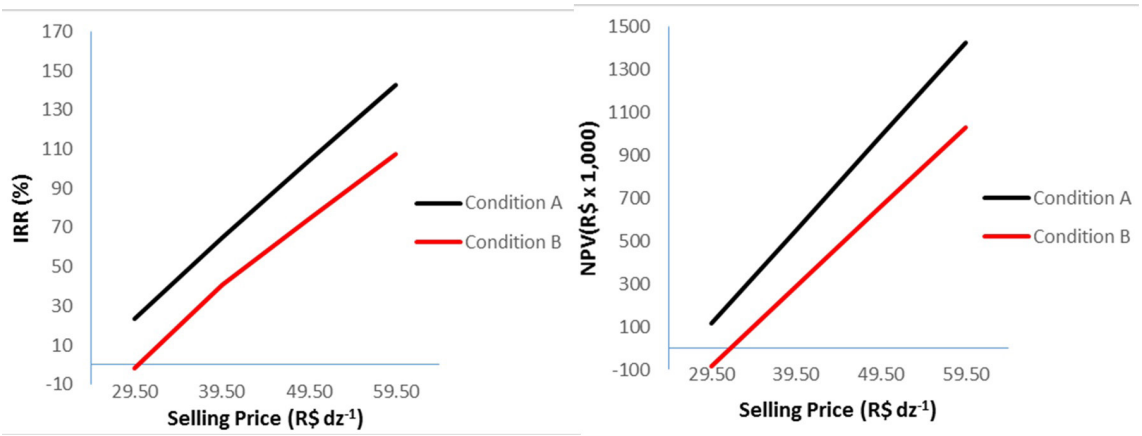

Figure 3. Sensitivity analysis of the production of scallops on the north coast of São Paulo: IRR and NPV respectively, considering more variations in the selling price per dozen of the product (R$ 29.50, 39.50, 49.50, 59.50). R$ 1.00 = US$ 0.32, values of July 2017.

DISCUSSION

The results obtained show the economic viability of scallop production on the São Paulo coast, even in a small area (0.2 ha), which can be attributed to the high commercial value of the product and to the adoption of structures that better explore the depth of production sites, such as lanterns with 10 floors or more

According to HENRIQUES *et al*. (2010), the largest capital investment in aquaculture enterprises is related to the acquisition of equipment and the construction of the cultivation structures that represent around 80% of the total invested. This data was confirmed in this study, in which the initial investment of R$ 185,730.63 became relatively high for small producers, limiting this activity to the medium or large entrepreneurs. One solution for small entrepreneurs enter the activity would be through a cooperative of producers. Another alternative would be the gradual expansion of the farm area according to profits, since more than 40% of the necessary investments to implement the cultivation are constituted by the acquisition of the growing lanterns, which can be acquired as production expand. This alternative is also interesting for

beginning growers that need to open sale fronts and thus expand their production according to the increase of demand.

One of the components that most affected production costs was the rental of the ranch at the seaside (17.7% of EOC), which serves to store the boat and material of daily use. This fact is attributed to the great valuation of properties located on the coast of the state of São Paulo. Seed acquisition also greatly affected the costs (14%), since PEREIRA *et al*. (1998) observed seed costs of only 8% of the CTP for *Crassostrea gigas* on in the southeastern coast of Brazil. This lower price can be explained by the different commercial values of the two products, since scallops reach higher selling prices and also by the lower selling price of oyster seed, whose is subsidized by the government.

The economic results of this study can be considered advantageous when compared to those recorded in the literature. In a study carried out in Rio de Janeiro, MOSCHEN (2007) reports that the production of scallops presents economic viability only at a medium scale (production above 30,000 scallops per cycle), obtained with at least eight long lines with 50 m of length each. Below this scale, the average operating cost shows values above the selling price. In that study the lanterns had only five floors and thus, the minimum production projected (30,000 scallops) is less than 50% of the production simulated in this analysis.

According to GIUSTINA *et al*. (2013), in an economic analysis based on data supplied by scallop producers from Santa Catarina State, the minimum selling price for that the activity be profitable, should be R$ 26.00 or US$ 13 per dozen in values of 2013. Considering the values of June 2017, this price approximately corresponds to the selling prices used in the present study (R$ 39.50 and R$ 49.50). With this selling price, the IRR is of 15.49%, far below those obtained in this work (minimum of 40.58%). In this scenario, these authors found a Breakeven Point (BP) of 6,697 dozen, that is, 50 to 100% higher than those determined in the present study (3,263 to 4,079 dozen). In Mexico, TAYLOR *et al*. (2006) compared the production of three *N. nodosus* culture systems and found better results for bottom culture on pillows without contact with the substrate, with NPV = US $ 28,631 and TIR = 27.0%, values close to the lowest results obtained in the present work. Scallop bottom cultivation usually has high cost of production due to the more complex handling and lower productivity per area, once it is carried out on a flat surface. In addition, the environmental conditions of that experiment resulted in longer cycle of growth (10-12 months) and higher mortality (20 to 50%) compared with the results in the north coast of São Paulo. The selling price of scallop dozen at R$ 31.72, in the worst condition proposed in this study, provides an IRR of 10.25%, stipulated here as the attractiveness rate of the analysis.

In this research, temporary labor costs correspond to about 18% of the Total Operational Cost, much of it due to the cleaning and removal of fouling. A solution to reduce this expense would be to cultivate at greater depths, where the amount of fouling is significantly reduced (LODEIROS *et al*., 1998). However, the higher costs of cultivation under these conditions should be considered.

Internal Rate of Return (IRR) ranged from 40.58 to 103.99%, affected by the survival rates (68.85 and 81.22%) and by selling prices of scallop (R$ 39.50 and 49.50 per dozen). In all of the proposed conditions, the project had an attractive profitability, considering the attractive rate of 10.25% (SELIC rate). The Payback Period (PP) in the condition of lower survival (68.85%) occurred in 2.5 years, which is less favorable than that found by HENRIQUES *et al*. (2010), who found that the return on invested capital in *Crassostrea* sp. oyster culture occurs in less than 20 months. However, it was better than that obtained by TAYLOR *et al*. (2006) for *N. subnodosus*, in the peninsula of Baja California, USA, where the PP was of approximately 6 years.

In Cananeia region, State of São Paulo, HENRIQUES *et al*. (2010) obtained for the growing phase of the mangrove oyster *Crassostrea* sp., survival rates between 64% and 80%. The IRR ranged from 20.65% to 102.11%, based on the selling prices of R$ 3.50 and R$ 4.50, respectively, in the two survival rates. In this study, survival conditions and IRR values were close, ranging from 40.58 to 103.99%. MENDOZA *et al*. (2003) showed that the cultivation of *Lyropecten nodosus* scallop in Japanese lanterns would be profitable if the unit were traded at US$ 0.25, equivalent to US $ 3.00 a dozen, with a profitability of 16%. The profit margin was US$ 2,102.85 and the relative profitability was 79.8%.

The cultivation of scallops in São Paulo state is still an incipient activity from a commercial point of view, but it has a favorable financial perspective, especially with the entry of medium-sized entrepreneurs. This activity will contribute to the jobs creation and self-employment for the coastal communities that have, nowadays, few income options due to the decline of artisanal fishing. The scallop cultivation is also a sustainable activity with low environmental impact, which can be developed even in areas of environmental protection, as is the case of most part of the São Paulo coast.

CONCLUSION

According to the indicators used, the cultivation of scallops proposed in this study showed economic feasibility, besides being attractive, due to the quick return of the invested capital considering the selling prices practiced in the state of São Paulo.

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