Economic analysis of common snook, *Centropomus undecimalis*, cultured in floating cages in southern Brazil

Fabiano Müller Silva[1], Vinicius Ronzani Cerqueira[2] and Giovanni Lemos de Mello[3]

Abstract - The economic viability of common snook culture was evaluated from a simulated marine farm with 20 cages of 225m³, with a production cycle of two years, fish with a final weight of 500g and annual production of 45 tons. To scale the production costs, the effective operating cost (EOC), total operating cost (TOC), total production cost (TPC) were considered. The indices for evaluating profitability were the Internal Rate of Return (IRR), the Return on Capital (RC) and the Net Present Value (NPV). The TPC was USD \$305,820 year^{-1}, with USD \$6.79 kg^{-1}. Sensitivity analysis by the variation of the feed conversion rate (FCR) reinforces the importance of good production practices, such as adequate food management, use of balanced diets. The factors: juvenile price, feed cost and sales price, more dependent on the market, require a greater ability of the producer to apply commercial and marketing strategies to contain the production cost and avoid the reduction of the sales price. The high cost of installing culture structures and management equipment suggests projects with a minimum rate of attractiveness of 23%, minimum volume of 6,500m³, productivity of 20kg m^{-3}, annual production of 65 tons, FCR below 1.6 and marketing price above USD\$8.39 kg^{-1}.

Index terms: Marine fish farming; internal rate of return; production cost; economic indices.

Análise econômica do robalo-comum, *Centropomus undecimalis*, cultivado em gaiolas flutuantes no Sul do Brasil

Resumo - A viabilidade econômica do cultivo do robalo-flecha foi avaliada a partir de uma fazenda marinha simulada com 20 tanques-rede de 225m³, com ciclo de produção de dois anos, peixes com peso final de 500g e produção anual de 45 toneladas. Os custos de produção considerados foram o custo operacional efetivo (COE), custo operacional total (COT), custo total de produção (CTP). Os índices para a avaliação da rentabilidade foram a Taxa Interna de Retorno (TIR), o Retorno do Capital (RC) e o Valor Presente Líquido (VPL). O CTP foi de USD\$305,820 ano^{-1}, com USD\$6.79 kg^{-1}. A análise de sensibilidade pela variação da taxa de conversão alimentar (TCA) reforça a importância das boas práticas de produção, como o manejo alimentar adequado, uso de dietas balanceadas. Os fatores: preço dos juvenis, custo da ração e preço de venda, mais dependentes do mercado, necessitam de uma maior habilidade do produtor em aplicar estratégias comerciais e mercadológicas para conter o custo de produção e evitar a redução do preço de venda. O alto custo de instalação das estruturas de cultivo e equipamentos de manejo sugere projetos com taxa mínima de atratividade de 23%, volume mínimo de 6.500m³, produtividade de 20kg m^{-3}, produção anual de 65 toneladas, TCA abaixo de 1,6 e preço de comercialização acima de USD\$8,39 kg^{-1}.

Termos para indexação: piscicultura marinha; taxa interna de retorno; custo de produção; índices econômicos.

Introduction

Cage aquaculture has grown rapidly during the past decades with the movement toward clustering existing cages as well as toward the development and use of more intensive cage-farming systems. In particular, the need for suitable sites has resulted in cage aquaculture accessing and expanding into new untapped open-water culture areas such as lakes, reservoirs, rivers, and coastal brackish and marine waters (FAO, 2007). Marine fish farming is one of the segments of aquaculture that arouses great interest and already accounts for 12.6% of fish farming in the world, totaling 6.3 million tons (FAO, 2016).

Marine fish farming is present in several countries, from snapper and European sea bass in the Mediterranean, groupers in Southeast Asia, Asian sea bass in Australia, red hake in the United States, and cobia in Central America, which are mostly carried out in marine cages (TUCKER, 2012; ALVAREZ-LAJONCHÈRE et al., 2013).

In Brazil, marine fish farming is still in its incipient. Although the Dutch have experimented in the 17th century the cultivation of common snook (*Centropomus undecimalis*, *C. parallelus*), mullets (*Mugil cephalus*), and carapebas (*Eugerres brasilianus*) in estuarine nurseries in the Recife region (PE) (CAVALLI, 2012), the only marine fish that are currently commercially cultivated on a small scale is the cobia (*Rachycentron*

Received on 24/06/2022. Accepted for publication on 31/10/22. DOI: https://doi.org/10.52945/rac.v35i3.1472

[1] Engenheiro Agrônomo, Mestrado em Aquicultura, Epagri/Centro de Desenvolvimento em Aquicultura e Pesca, Florianópolis, Santa Catarina, Brasil. E-mail: fabiano@epagri.sc.gov.br
[2] Oceanólogo, Dr., Universidade Federal de Santa Catarina, Departamento de Aquicultura, Florianópolis, Santa Catarina, Brasil. E-mail: vinicius.cerqueira@ufsc.br
[3] Engenheiro de Aquicultura, Dr., Universidade do Estado de Santa Catarina, Laboratório de Aquicultura, Laguna, Santa Catarina, Brasil. E-mail: giovanni.mello@udesc.br

canadum). In this sense, several species are being prospected, among which is the common snook (*C. undecimalis)*. Starting in 2009, young forms of common snook were produced through hormonal inductions from breeders kept in the laboratory (CARVALHO-FILHO, 2009), starting a series of experiments for the development of a technological package for the culture of the species.

In view of the potential that exists in Brazil for breeding the common snook, Sanches et al. (2014) proved the economic viability of cultivation on shrimp farms in the Northeast region of Brazil. In the case of cages, performance was evaluated by Oviedo-Pérez et al. (2013) in Mexico, obtaining an average final weight of 830g in two years of cultivation (from 3.3g juveniles), with an average temperature of 26.4°C. Market studies carried out by Barni et al. (2013) considered the slaughter weight of 500g for the species economically viable for the market.

The sustainability of aquaculture production systems is based on three interrelated aspects: production technology, social and economic environmental, and climatic impacts and influences (AGNESE et al., 2008; ELER et al., 2008; KIMPARA et al., 2010; ROCHA et al., 2013; GRILLONE et al., 2014). The structuring of a technological package depends on studies to understand the life cycle of the species that will technically make the reproduction, nutrition, and productive indicators of the culture of the species possible, but in addition also studies the biological area. The works must research the aspects of the bioeconomy culture of the species (MIAO & TANG, 2002; MELLO et al., 2009; SANCHES et al., 2013).

The objective of this article is to evaluate the economic and financial performance of the production of bass in cages, in the climatic conditions of the central-north coast of the state of Santa Catarina. Production and productivity indicators obtained in a study carried out between December/2013 and April/2015 were used to elaborate production costs. Two methods of analysis were used: the financial feasibility analysis that uses the net present value (NPV), the discounted payback (DPBT) and the internal rate of return (IRR) and the economic analysis based on the production cost estimate of sea bass in the year 2016.

Material and methods

The economic and financial analysis was conducted on a simulate mariculture farm on the southern coast of Brazil that produced common snook (*C. undecimalis*). The inshore fish farm with 20 surface-based cages of 225m³, each with a flotation structural part constituted by annular tubes of high density polyethylene (HDPE), composed of 160mm tubes, 7mm wall thickness, and a 7.6m diameter. The cages were installed in 8.0m of which a set of nets with different mesh openings were coupled, varying according to different stages of culture (Table 1).

The culture cycle was 730 days. Fingerlings weighing 10g were fattened for 730 days, until reaching a slaughter weight of 500g. The estimated annual average production of common snook was 45t, deriving from a fish biomass of 20kg m^{-3}, at an average water temperature of 23.3°C. Cultivation was based on technical indicators of production and productivity: survival, starting density, flat feed conversion, specific growth rate, as well as the management strategies and diet used in the characterization of culture that followed data obtained in studies by Oviedo-Pérez et al. (2013) & Silva et al. (2021) (Table 2).

Zootechnical Assumptions

The system evaluated consisted of three growth phases with different stocking densities and quantities of cages used for each stage in 4 production cycles (Table 3).

The fish feed consisted of a commercial ration with high protein content (45% to 55% Crude Protein) and energy (100% to 120% Crude fat) that was supplied twice a day (8:00h and 17:00h) by means of automatic feeders in an amount corresponding to 1% to 3% of the stored biomass, varying according to the water temperature.

Economic analysis

The financial viability of the investment was analyzed by three main methods: the IRR (Internal

Table 1. Nets specifications used in cages (7.5 m Ø) for the growth of common snook
Tabela 1. Redes utilizadas nos tanques-rede (7,5 m de Ø) de cultivo do robalo-flecha

Fish Weight Range	Net Specifications
10–100 g	6 mm mesh, useful height of 3.50 m
100–250 g	12 mm mesh, useful height of 5.0 m
250–500 g	20 mm mesh, useful height of 5.0 m

Table 2. Phases of growth, density, and main zootechnical parameters for juvenile common snook, *Centropomus undecimalis*, in cages. Studies by Oviedo-Pérez et al. (2013) and Silva et al. (2016)
Tabela 2. Fases de crescimento, densidade e principais parâmetros zootécnicos para juvenis de robalo-comum, *Centropomus undecimalis*, em tanques-rede. Estudos de Oviedo-Pérez et al. (2013) e Silva et al. (2016)

Growth phase	Starting weight (g)	Final weight (g)	Survival (%)	Starting density (fish m^{-3})	CP[1] Feed	FCR[2]	SGR[3] (% weight day^{-1})
Fingerling	10.0	100.0	85	195	55%	1.5	0.99
Pre-ongrowth	100.0	250.0	95	70	45%	1.9	0.37
Final-ongrowth	250.0	500.0	95	40	45%	2.3	0.37
Average						**2.0**	**0.54**

[1]Crude Protein, [2]Feed Conversion Rate, [3]Specific Growth Rate

Table 3. Production schedule of common snook in cages, in the first four cycles
Tabela 3. Cronograma de produção de robalo-flecha em tanques-rede, nos quatro primeiros ciclos

Growth Phase	1st. Cycle	2nd. Cycle	3rd. Cycle	4º Cycle
Stock (10 g)	November/00[1]	November /01	November /02	November /03
Transfer I (100 g)	July/01	July /02	July /03	July /04
Transfer II (250 g)	March/02	March /03	March /04	March /05
Harvest (500 g)	**October /02**	**October /03**	**October /04**	**October /05**

[1] years of project progress

Rate of Return) which equals the anticipated cash flow to the value of the investment, the Payback (Return Time) which calculates the time it will take for the investment if pay, and the NPV (Net Present Value) that compares the investment with the expected return, calculating the real investment gain. These indicators serve as minimum decision criteria to assess the feasibility of projects.

Before analyzing the investment evaluation methods, the cash flow calculation was performed for a period of 10 years, where the initial investment and working capital necessary to maintain the first production cycle were included in the first year. The NPV is the sum of the Present Value (PV) of all projected cash flows.

FV = Future Value
i = fees (minimum attractiveness rate MAR)
n = years

The value of the IRR varies with the conditions of remuneration of capital in the financial market, in this study we used a Minimum Attractiveness Rate (MAR) of 23% (ASSAF NETO, 1992; MARQUEZAN, 2012) and considered the full investment in the year zero.

Production Cost

Production costs were estimated according to the methodology proposed by Matsunaga et al. (1976) and corroborated in recent publications (SANCHES et al., 2008; KODAMA et al., 2011). This methodology evaluates production costs where:

EOC – Effective Operating Cost: all expenses incurred during a crop year and that are spent in the period, plus the Opportunity Cost of the capital necessary to cover these expenses. This "simple" calculation is widely used by fish farmers who do not have adequate financial management of their ventures.

TOC – Total Operating Cost: (EOC + Depreciation) sum of the EOC with the calculation of the depreciation of machines, implements, equipment, and structures, over the years.

TC – Total Cost: (TOC + Opportunity Cost) sums the TOC and the Opportunity Cost on the fixed capital invested, including land remuneration.

Regarding the depreciation of works and equipment, it was considered a useful life of 20 years for the shed and 10 years for the cages, metal piles, ferry, and aluminum boat. The other equipment and material has a useful life of 5 years. The value of the interest on the invested capital was established at 12% p.a.

After quantifying the investment and operating costs, in order to provide a more exhaustive economic assessment of aquaculture common snook production systems, we apply a sensitivity analysis, varying the sale price of the fish. The two main cost items in the production process were: feed cost and fingerling cost. An indicator of zootechnical performance was the feed conversion rate and a structural dimensioning item (cage volume). Sensitivity analyses is a useful exercise to evaluate the influence of assumptions in the profitability calculations. Profitability analysis is useful to evaluate effects of one or several simultaneously changing cost factors. Each parameter was varied above and below its baseline value, determining for each aquaculture production a new financial index system and comparing the effect on the IRR.

Results and discussion

The amount required for the implementation of the common snook marine farm analyzed was US$317,422.28 (Table 4), with the costs of acquiring the cages, handling raft, shed and automatic feeders accounting for 68.2%, 6.8%, 6.4%, and 4.8% of the total investment, respectively. Among the few economic feasibility studies with marine fish farming in Brazil, Sanches et al. (2014) evaluated the culture of common snook in a shrimp farm (20.0ha) in northeast Brazil, where the implementation costs were considered only as structural adjustments on the farm, in the total amount of USD$109.92 thousand, much lower than the USD$305.8 thousand obtained in this study. Another study with offshore cages, Sanches et al. (2008) evaluated the economic feasibility of creating cobia, with an investment of USD$181.79 thousand (updated by the National Consumer Price Index - INPC) for the installation of 24 cages (98m^3 each) and 2,352m^3, with a cost of USD $7,557.25 per cage or USD$77.10 m^{-3}. In the present work, although the individual value of the cages reached a higher value (USD$14.5 thousand), the cost of implantation of the cubic meter was lower (USD$64.54 m^{-3}).

Equipment depreciation totaled USD$40,061.34 per year and the amount of interest on invested capital was USD$38,252.50 per year. Cost, depreciation, and interest on invested capital items totaled USD$78,202.91, and together, they were more representative compared to the annual expenditure on the purchase of juveniles and payment of labor. The production cost of the crop was USD$305,820.06 with feed being the component with the highest production cost (USD$97.10 thousand) around 32.0%, followed by juveniles of common snook (31.3%), depreciation (13.2%), interest on invested capital (12.6%), and labor (8.2%), which together represent 97.3% of the total cost of production (Table 5).

This strong impact of structures on production cost, raises a need to re-

Table 4. Investments necessary for growth of common snook in cages (2016) in USD[1,2]. Exchange USD 1.00 = R$ 3.93
Tabela 4. Investimentos necessários para engorda do robalo-flecha em tanques-rede (2016) em USD[1,2]. Câmbio USD 1.00 = R$ 3.93

	Unity	Amount	Total price[1]	Lifespan (years)	Depreciation (a)[3]	Annual investment interest (b)[4]	Total (a)+(b)
1. Works and installations							
1.1. Shed (100 m²)	Unity	1	20,356.23	20	1,017.81	2,442.75	3,460.56
1.2. Cage (7.6 m Ø)	Unity	20	149,236.64	10	14,923.66	17,908.39	32,832.06
1.3. Installation of stakes, cables, buoys	Several	114	8,702.29	10	870.23	1,044.27	1,914.50
2. Equipment							
2.1. Nets (cultivation and anti-bird)	Unity	20	67,253.30	5	13,450.66	8,070.40	21,521.06
2.2. Multiparameter probe, photocolorimeter	Several	1	7,124.68	5	1,424.94	854.96	2,279.90
2.3. Microcomputer and printer	Unity	1	5,343,51	5	1,068.70	641.22	1,709.92
2.4. Telephones and radio communicator	Unity	1	763.36	5	152.67	91.60	244.27
2.5. Freezer and refrigerator	Several	1	1,145.04	5	229.01	137.40	366.41
2.6. Digital scales 1 kg and 50 kg	Unity	1	1,272.26	5	254.45	152.67	407.12
2.7. Automatic feeders	Unity	20	15,267.18	5	3,053.44	1,832.06	4,885.50
2.8. High pressure water washer	Unity	2	1,017.81	5	203.56	122.14	325.70
2.9. Miscellaneous puddles	Several	1	254.45	5	50.89	30.53	132.32
2.10. Plastic boxes, trays and glassware	Several	1	2,137.40	5	427.48	256.49	683.97
2.11. PPE's: Vests, gloves, covers	Unity	10	508.91	5	101.78	61.07	162.85
2.12. Ferry handling 10 m, engine 150 HP	Unity	1	21,628,50	10	2,162.85	2,595.42	4,758.27
2.13. Aluminum boat, 6 m, 25 HP engine	Unity	1	6,692.11	10	669.21	803.05	1,472.26
3. Documentation and preparation							
3.1. Licensing fees	Unity	1	2,544.53			305.34	305.34
3.2. Preparation of Technical Project[5]	%	3	6,174.07			740.89	740.89
Total (US$)			**317,422.27**		**40,061.35**	**38,090.67**	**78,202.90**

[1] Values expressed in US$
[2] Average values based on a 3.5 hectare farm and 20 cages
[3] Calculation using the linear method
[4] 12% p.a. on invested capital
[5] Calculation of payment for project preparation and documentation [3.2. = (1. + 2. + 3.1.) X 2%]

search lower cost floating structures, but with equal functionality and strength. Structures of 7.6 m in diameter, built in galvanized steel, 100 L floats and wooden walkway, cost USD$2,544.53 unit^{-1}, which would reduce investments to USD$50,890.58, 34.10% of the value of HDPE. This represents a reduction of USD$0.49 kg^{-1} in the total cost of production, from USD$6.78 to USD$6.30 kg^{-1}. The reduction in investment also made it possible to reach an IRR of 23% with a sales price of USD$7.00 kg^{-1}.

The production costs of a kilogram of common snook in the project were as follows: the EOC was USD$4.62 kg^{-1}, TOC was equivalent to USD$5.92 kg^{-1}, and TPC was equal to USD$6.79 kg^{-1}. The difference between the calculation of EOC and TPC was USD$2.17 kg^{-1}. The TPC is high compared to the cost of USD$3.67 kg^{-1} obtained by Sanches et al. (2014) for the same species in excavated shrimp ponds, with an estimate of 1kg year^{-1}, well above the 0.5kg every two years proposed for the cage system in southern Brazil. The difference in growth generated a production cost that was 83.7% less for common snook semi-intensive culture in ponds, which may be associated with factors related to the production system, such as lower density and access to natural food (forage fish, crustaceans, insects, and benthos), which does not happen in the cage system where fish depend exclusively on balanced rations. The supplementation of fish nutrition by natural food may have been a determining difference in growth as we do not yet have a specific ration for the nutritional requirements of common snook. Added to this, the fact that the common snook is a tropical species and does not grow well at medium or low temperatures. Mello et al. (2016), cultivating juveniles of the species at different temperatures and salinities, found a 65% higher growth at a temperature of 28°C when compared to a temperature of 25°C.

The study considered the average temperature of 23.3°C, recorded for the period, in Florianópolis. In Mexico, the growth of common snook in cages started from 3.3g, reaching 830.0g in 2 years, at an average temperature of 26.4°C (OVIEDO-PÉREZ et al., 2013), much lower than those presented by Sanches et al. (2014). Water temperature is considered one of the most important environmental variables, as it directly affects metabolism (JIAN et al., 2003). Most animals have wide ranged temperature tolerance, however, the range of environmental comfort, which provides the ideal conditions for the performance of the functions of growth and reproduction is specific (SCHMIDT-NIELSEN, 1996). For the common snook, stenothermia seems to strongly influence the economic viability of the enterprises (MARSHALL, 1958; HOWELLS et al., 1990).

Another important cost is spending on juveniles (31.3%), ranging from R$1.00 to R$2.00 unit^{-1} (MELLO et al., 2009; SANCHES et al. 2014), depending on the commercial weight of juveniles. For southern Brazil, the reproduction of the common snook takes place in the summer (January to March). Thus, the laboratories will need to stock the juveniles for a few subsequent months in winter and spring (April to October), increasing the commercial price.

As there are no commercial culture of common snook in Brazil, we use as a reference the average price of USD$7.88 kg^{-1} practiced at Companhia de Entrepostos e Armazéns Gerais de São Paulo (CEAGESP) for snook from fishing. In addition to this value, the maximum value of USD$8.91 kg^{-1} was also used to calculate the profitability indicators (IRR and NPV) (Table 6).

Table 6. Indicators of profitability (IRR and NPV) and time of return on investment (pay-back) for a marine common snook fish farming in cages. (USD $). Exchange USD 1.00 = R$ 3.93

Tabela 6. Indicadores de rentabilidade (TIR e VPL) e tempo de retorno do investimento (pay-back) para piscicultura marinha de robalo-flecha, em tanques-rede. (USD $). Câmbio USD 1.00 = R$ 3.93

	Annual cash flow	**Marketing price (kg)**	
	Year	**US$ 7.88**	**US$ 8.91**
Investment in year zero	0	-317,422.28	-317,422.28
	1	-167,133.61	-167,133.61
	2	90,728.99	136,530.51
	3	90,728.99	136,530.51
	4	90,728.99	136,530.51
	5	90,728.99	136,530.51
	6	90,728.99	136,530.51
	7	90,728.99	136,530.51
	8	90,728.99	136,530.51
	9	90,728.99	136,530.51
	10	90,728.99	136,530.51
	11	185,805.32	231,606.85
Internal rate of return (IRR)		14.59	24.35
Net present value (NPV)	Rate 12% p.a.	18,396.84	249,458.31
	Rate 24% p.a.	-173,890.00	-37,894.32
	Rate 36% p.a.	-260,333.43	-171,106.21
Pay-back		10 years	7 years

For the value of USD$7.88 kg^{-1}, the NPV only becomes positive when the MAR is equal to or less than 12% p.a. When raised, the sale price started at USD$8.90 kg^{-1}, which was based on an annual interest rate of 12% p.a. It is possible to reach a positive NPV of USD$249,5 thousand and see an increase in the IRR to 24.35%.

The IRR calculated at 14.59% was very close to the main financial investments of the study period[2], such as savings (8.3% p.a.), the Bank Deposit Certificate (BDC) (12.91% p.a.), the Certificates of Interbank Deposit (CID) (13.73% p.a.), and the Special System for Settlement and Custody (SELIC) (13.74% p.a.).

Despite these positive results, five sensitivity analyzes were conducted to find indications of improvements in production and marketing processes, which allowed for an increase in economic results.

The Sensitivity analysis for variations in feed conversion ratio (FCR) showed significant fluctuations in IRR values, which tend to increase as FCR decreases (Figure 1). Among the sensitivity analyses evaluated, only the variation of FCR can be manipulated by the producer through good production practices, confirming the importance of adequate food management, use of balanced diets for the species at each stage of cultivation. It should also be noted that the FCR for common snook is dependent on weather conditions (higher temperatures) influencing the variation of the project's IRR.

The other factors analyzed: cost of feeding, price of juveniles and sale price, directly affect the economic viability of the enterprise, but are market dependent and cannot be manipulated by the producer, making it difficult to reach a proposed IRR of 23%. These factors will make it difficult to reach a proposed IRR of 23%, increasing the producer's responsibility to apply commercial and marketing strategies to contain production costs and avoid reducing the sale price, properly negotiating their production on the market (SGROI et al., 2014; TUDISCA et al., 2014a, b).

The investment becomes more attractive with feed prices below US$ 0.89 kg^{-1} (Figure 2), mainly because feed is one of the main production costs of aquaculture. The cost of food in this study corresponded to 32% of the total cost, different from Barbosa et al. (2011), where they exceeded 50% of the total costs.

The price of fingerlings may vary with laboratory productivity and market availability (Figure 3). France, Spain and Greece, with commercial production of sea bass and sea bream, sell the juvenile of 10g at 0.6 to 1.00 €, which leads us to believe that with the establishment of commercial common snook culture, prices of juveniles may also be more accessible.

The sale of common snook estimated at USD$8.65 kg^{-1} is far from the current reality of the market, whose average price is USD$7.89 kg^{-1}. The simulations presented in Figure 4 show that prices below USD$7.88 kg^{-1} reduce the IRR, making the investment less attractive. On the other hand, the increase of USD$1.03 in the kilo of fish, USD$8.91 kg^{-1}, in addition to increasing the IRR to 24.35%, anticipates the return of the project from 10 to 7 years (Table 6) .

Sensitivity analysis for variations in cage volume showed significant fluctuations in IRR values. By maintaining the stocking density of 20fish m^{-3}, it is possible to observe a reduction in TPC (USD$ kg^{-1}) as the volume of net cages increases, reflecting positively on the IRR. In the present study, depths of less than 4m with a volume of 175m³ generated a negative IRR. Thus, the IRR values ranged from -0.10 (TPC of USD$6.67 kg^{-1} and cage volume of 150m³) to 25.70 (TPC of USD$5.28 kg^{-1} and cage volume of 375m³), as shown in Table 7. An example of this is the cultivation of marine fish around the world, such as salmon, sea bass and sea bream, practiced in ponds of 25m to 50m in diameter and depths of 12m, reaching volumes from 5,800m³ to 23,550m³.

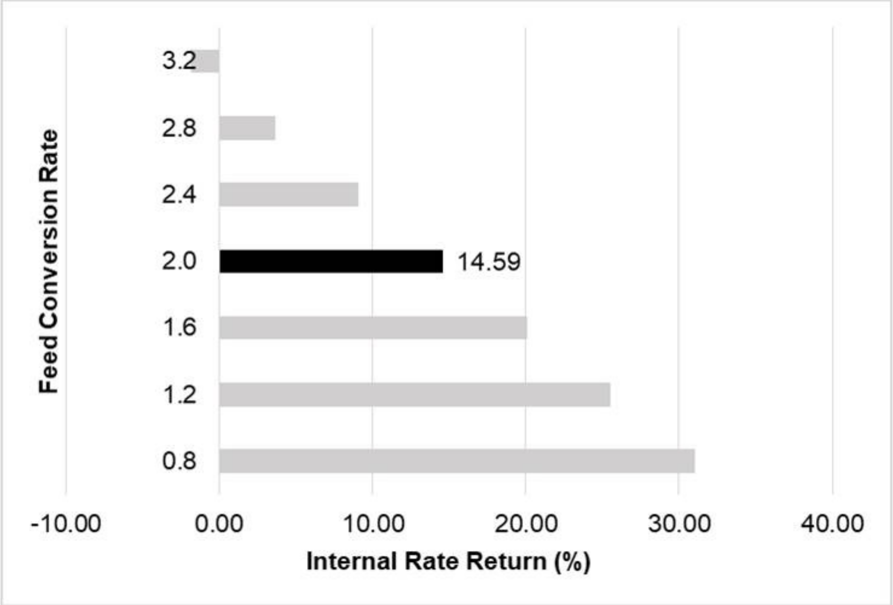

Figure 1. Sensitivity analysis based on the effect of Apparent Feed Conversion, on the Internal Rate of Return (IRR)

Figura 1. Análise de sensibilidade baseada no efeito da taxa aparente de conversão alimentar sobre a Taxa Interna de Retorno (TIR)

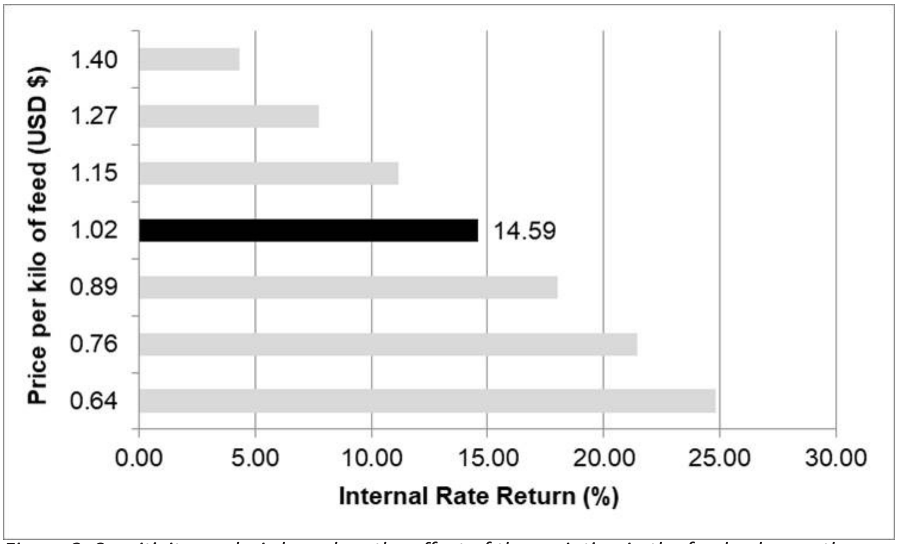

Figure 2. Sensitivity analysis based on the effect of the variation in the feed value on the Internal Rate of Return (IRR)

Figura 2. Análise de sensibilidade baseada no efeito da variação do valor da alimentação sobre a Taxa Interna de Retorno (TIR)

Conclusion

Under the conditions and assumptions attributed to the common snook culture in the present study, the marine farm demonstrates economic and financial viability. Based on the results obtained, we can conclude that the best scenarios depend directly on good production practices, the producer's ability to apply commercial and marketing strategies to contain production costs and avoid reducing the sale price.

Considering temperature as the main condition for the good zootechnical performance of the species, it is recommended to install common snook cultures in regions with average temperatures above 23.3°C.

Acknowledgments

Research carried out with the support of the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina – FAPESC nº 7048/2010-3 and the National Council for Scientific and Technological Development – CNPq nº 406844/2012-7

References

AGNESE, C.; D'ASARO, F.; GRILLONE, G.; DRAGO, A. Comparison of temperature data collected in urban and agricultural areas surrounding. **Italian Journal of Agrometeorology**, v.13, p.48–49, 2008.

ALVAREZ-LAJONCHÈRE, L.S.; IBARRA-CASTRO, L. Aquaculture species selection method applied to marine fish in the Carib-

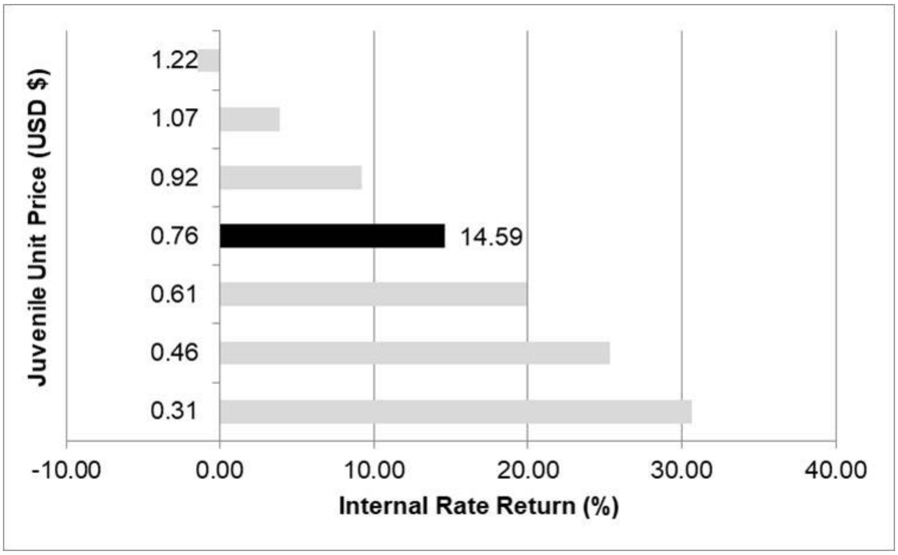

Figure 3. Sensitivity analysis based on the variation of the juvenile unit price on the Internal Rate of Return (IRR)
Figura 3. Análise de sensibilidade baseada na variação do preço unitário do juvenil na Taxa Interna de Retorno (TIR)

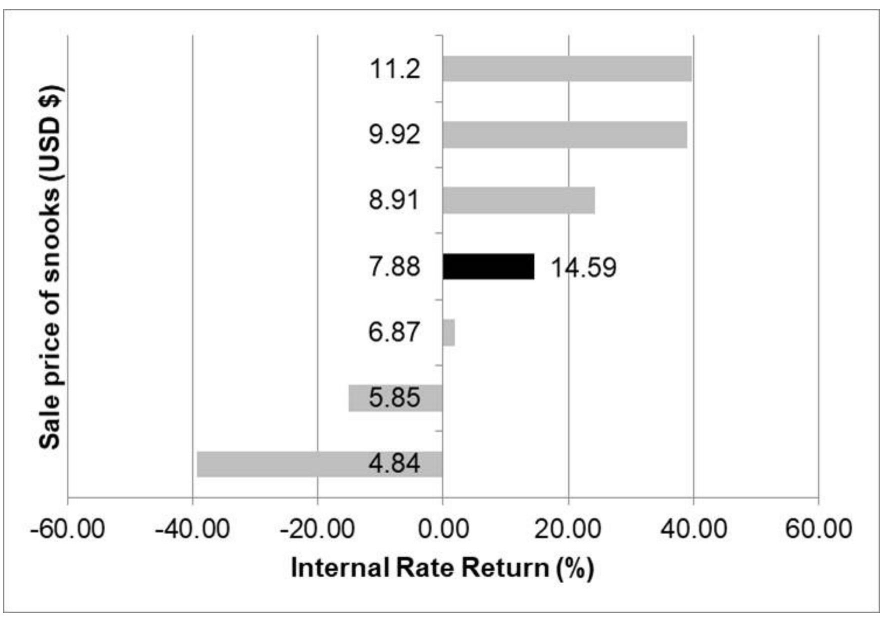

Figure 4. Sensitivity analysis based on the effect of the selling price of 500 g of common snook on the Internal Rate of Return (IRR)
Figura 4. Análise de sensibilidade baseada no efeito do preço de venda de 500 g de robalo-flecha sobre a Taxa Interna de Retorno (TIR)

bean. **Aquaculture**, v.408, p.20-29, 2013. DOI: https://doi.org/10.1016/j.aquaculture.2013.05.020.

ASSAF NETO, A. Os Métodos Quantitativos de Análise de Investimentos. **Fundação Instituto de Pesquisas Contábeis, Atuariais e Financeiras,** Caderno de Estudos [online], n.6, p.01-16, 1992. DOI: https://doi.org/10.1590/S1413-92511992000300001

BARBOSA, M.C.; NEVES, F.F.; CERQUEIRA, V.R. Taxa alimentar no desempenho de juvenis de robalo-peva em tanque-rede. **Acta Scientiarium. Animal Sciences [online]**, v.33, n.4, p.369-372. 2011. DOI: https://doi.org/10.4025/actascianimsci.v33i4.11413.

BARNI, E.; AMARAL, H. DO; MELLO, G.L. DE; SILVA, M.C.; CERQUEIRA, V.R. E GARCIA, S. **Prospecção de mercado para o robalo de cultivo em municípios litorâneos de Santa Catarina**. Florianópolis, SC, 2013. 55p. (Epagri. Documentos, 243).

CARVALHO-FILHO, J. Especialista produz com sucesso alevinos de robalo flecha. **Panorama da Aquicultura**, v.19, n.114, p.58-59. 2009.

CAVALLI, R.O. Com excelentes condições ambientais, piscicultura marinha carece de investimentos. **Visão Agrícola (Usp/Esalq)**, n.11, p.18-23. 2012.

ELER, M.N.; MILLANI, T.J. Métodos de estudos de sustentabilidade aplicados à aquicultura. **Revista Brasileira de Zootecnia [online]**, v.36, p.33-44. 2008. DOI: https://doi.org/10.1590/S1516-35982007001000004.

FAO. **Cage aquaculture – Regional reviews and global overview**. Rome, 2007. 241 p. (FAO. Fisheries Technical Paper, 498)

FAO. **The State of World Fisheries and Aquaculture**. Rome, 2016. 223p.

GRILLONE, G.; BAIAMONTE, G.; D'ASARO, F. Empirical determination of the average annual runoff coefficient in the Mediterranean area. **American Journal of Applied Sciences**, v.11, n.1, p.89–95. 2014. DOI: https://doi.org/10.3844/ajassp.2014.89.95.

HOWELLS, R.G.; SONSKI, A.J.; SHAFLAND, P.L.; HILTON B.D. Lower temperature tolerance of snook, *Centropomus undecimalis*. **Northeast Gulf Science**, v.11, p.55-158. 1990. DOI: https://doi.org/10.18785/negs.1102.08.

JIAN C-Y; CHENG, S.Y.; CHEN, J.C. Temperature and salinity tolerances of yellowfin sea bream, *Acanthopagrus latus*, at different salinity and temperatures levels. **Aquaculture Research**, v.34, n.2, p.175-185. 2003. DOI: https://doi.org/10.1046/j.1365-2109.2003.00800.x.

KIMPARA, J.M.; ZAJDBAND, A.D.; VALENTI, W.C. Medindo a sustentabilidade na aquicultura. **Sociedade Brasileira de Limnologia,** V.38, n.2, p.73-79. 2010.

KODAMA, G.; ANNUNCIAÇÃO, W.F.; SANCHES, E.G.; GOMES, C.H.A.M.; TSUZUKI, M.Y. Economic feasibility of clown fish, *Amphiprion ocellaris*, in recirculation system. **Boletim do Instituto de Pesca**, v.37, n.1, p.61-72. 2011.

MARQUEZAN, L.H.F.; BRONDANI, G. Análise de Investimentos. **Revista Eletrônica de Contabilidade**. v.3, n.1, p.35. 2012. DOI: https://doi.org/10.5902/198109466137. Disponível em: https://periodicos.ufsm.br/contabilidade/article/view/21. Acesso em: 4 out. 2022.

MARSHALL, A.R. A survey of the snook fishery of Florida, with studies of the biology of

Table 7. Sensitivity analysis based on the variation of the volume of cages, for the growth of common snook, on the Total Production Cost (TPC) and Internal Rate of Return (IRR) (in USD $). Exchange USD 1.00 = R$ 3.93.
Tabela 7. Análise de sensibilidade baseada na variação do volume dos tanques-rede, para o cultivo de robalo-flecha, sobre o Custo Total de Produção (CTP) e a Taxa Interna de Retorno (TIR) (em USD $). Câmbio USD 1.00 = R$ 3.93

Net Useful Height (m)	Volume cage (m^3)	Revenue (US$)	TPC (USD $/ cycle)[a]	Production (kg/cycle)[b]	TPC USD$/kg (a/b)	IRR
3.5	150	236,641.22	199,980.87	30,000	6.67	- 0.10
4	175	276,081.42	221,398.20	35,000	6.33	6.19
4.5	200	315,521.63	242,815.52	40,000	6.07	10.92
5*	**225**	**354,961.83**	**264,232.85**	**45,000**	**5.87**	**14.59**
5.5	250	394,402.04	285,650.17	50,000	5.71	17.53
6	275	433,842.24	307,067.50	55,000	5.58	19.93
6.5	300	473,282.44	328,484.83	60,000	5.47	21.93
7	325	512,722.65	353,705.21	65,000	5.44	22.88
7.5	350	552,162.85	375,122.53	70,000	5.33	24.39
8	375	591,603.05	396,539.86	75,000	5.29	25.70

* Cage volume used in the simulation of the evaluated culture structure.

the principal species, *Centropomus undecimalis* (Bloch). **Florida State Board Conservation Technical Series,** v.22, p.39, 1958.

MATSUNAGA, M.; BEMELMANS, P. F.; TOLEDO, P. D.; DULLEY, R. D.; OKAWA, H.; & PEDROSO, I. A. Metodologia de custo de produção utilizada pelo Instituto de Economia Agrícola. **Agricultura em São Paulo**. v.23, n.1, p.123-139, 1976.

MELLO, G.L.; FARIAS, A.P.; FRANCISCO, C.A.; SERAFIM, F.T.; VARELA, D.G.; AGUIAR, A.; PETERSEN, R.L. Policultivo de tilápias e camarões marinhos: consolidando um pacote tecnológico modelo para o Brasil - Parte 2. **Revista Aquicultura & Pesca**, v.1, p.48-55, 2009.

MELLO, G.L. DE; JERÔNIMO, G.T.: TANCREDO, K.R.; BROL, J.; ALMEIDA, E.J. DE; MARTINS, M.L.; TSUZUKI, M.Y. 2016. Development and health status of *Centropomus undecimalis* parasitized by *Rhabdosynochus rhabdosynochus* (Monogenea) under different salinity and temperature conditions. **Brazilian Journal of Veterinary Parasitology**, v.24, n.3, p.350-356, 2016. ISSN 0103-846X (Print), ISSN 1984-2961 (Electronic). DOI: http://dx.doi.org/10.1590/S1984-29612015062.

MIAO, S.; TANG, H.C. Bioeconomic analysis of improving management productivity regarding grouper *Epinephelus malabaricus* farming in Taiwan. **Aquaculture**, v.211, p.151-169, 2002. DOI: https://doi.org/10.1016/S0044-8486(02)00190-4.

OVIEDO-PÉREZ, A.; SANCHEZ-ZAMORA, A.; OVIEDO-ACEVES, A.; PINEDA-SANDOVAL, C. *Centropomus undecimalis* obtained in Lab: Growth of juvenile in floating cages in Veracruz, México. *In*: Strike A Chord for Sustainable Aquaculture. 2013, Nashville. **Anais. Book of Abstracts, World Aquaculture Society.** 2013.

ROCHA, C. M. C. D., RESENDE, E. K. D., ROUTLEDGE, E. A. B.; LUNDSTEDT, L. M. Avanços na pesquisa e no desenvolvimento da aquicultura brasileira. **Pesquisa agropecuária brasileira**, v.48, n.8, p.4-6, 2013. ISSN 1678-3921. DOI: https://doi.org/10.1590/S0100-204X2013000800iii.

SANCHES, E. G.; SECKENDORFF, R.W.V.; HENRIQUES, M.B.; FAGUNDES, L.; SEBASTIANI, E.F. Viabilidade econômica do cultivo do bijupirá (*Rachycentron canadum*) em sistema offshore. **Informações Econômicas,** v.38, p.42-51, 2008.

SANCHES, E.G.; MELLO, G.L.; AMARAL JÚNIOR, H. First occurrence of skeletal anomalies in common snook juveniles. **Boletim do Instituto de Pesca**, v.39, n.1, p.77-83, 2013.

SANCHES, E.G.; SILVA, F.C.; RAMOS, A.P.F.A. Viabilidade econômica do cultivo do robalo-flecha em empreendimentos de carcinicultura no Nordeste do Brasil. **Boletim do Instituto de Pesca**, v.40, p.577-588, 2014.

SCHMIDT-NIELSEN, K. **Fisiologia Animal: Adaptação e Meio Ambiente**. 5.ed. São Paulo, SP: Santos Livraria e Editora, 1996. 600 p.

SGROI, F.; DI TRAPANI, A.M.; TESTA, R.; TUDISCA, S. Strategy to increase the farm competitiveness. **American Journal of Agricultural and Biological Sciences**, v.9, n.3, p.394–400, 2014. DOI: https://doi.org/10.3844/ajabssp.2014.394.40.

SILVA, F.M.; SILVA, B.C.; CERQUEIRA, V.R. Different densities of common snook reared in marine cages in Southern Brazil. **Boletim do Instituto de Pesca**, v.47, 2021. DOI: https://doi.org/10.20950/1678-2305/bip.2021.47.e643.

TUCKER, J.W. **Marine Fish Culture.** Ed. Springer Science & Business Media Publishing Company, 2012. 750p.

TUDISCA, S.; DI TRAPANI A.M.; DONIA E.; SGROI F.; TESTA R. Entrepreneurial strategies of Etna wine farms. **International Journal Entrepreneurship Small Bus**, v.21, p.155-164, 2014a. DOI: https://doi.org/10.1504/IJESB.2014.059470.

TUDISCA, S.; DI TRAPANI A.M.; SGROI F.; TESTA R. Economic evaluation of PDO introduction in Sicilian orange farms. **Quality-Access Success**, v.14, n.139, p.99-103, 2014b.