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Research Article

A cost-benefit analysis of three gillnet fisheries in Santa Catarina, Brazil: contributing to fisheries management decisions

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ABSTRACT. This cost-benefit analysis of three industrial bottom gillnet fisheries that operated in SE/S Brazil during 2009, had a double purpose: to determine the economic and financial performance of the average gillnet vessel in the coastal whitemouth croaker (*Micropogonias furnieri*), the gulf hake (*Urophycis mystacea)* and monkfish (*Lophius gastrophysus*) fisheries and to determine the expected effects of applying fishing gear regulation (MPA/MMA Nº12/2012) on the performance of the whitemouth croaker fishing fleet. Crucial to this cost-benefit analysis was to collect data through interviews to vessel owners on these fishing fleets cost structures and their fishing costs levels. Three economic and financial performance indicators were used to assess the condition of these fishing fleets: Net Present Value (NPV), Internal Rate of Return (IRR) and Profitability Index (PI). Results showed different costs levels between fishing fleets but, similar relative importance of cost components across fleets: with running costs being the highest, followed by vessel and labor costs in order of importance, except in the gulf hake fishing fleet. Results from the economic and financial performance assessment showed that these three fishing fleets were in a fragile economic and financial condition, all having IRRs lower that 20% and PIs of 1.7 or lower, too low for a high risk activity like fisheries. This problem been more acute in the whitemouth croaker fishing fleet with the lowest IRR (12.11%) and PI (1.2). Potential effects of applying the fishing regulation showed marginal improvements in the fragile condition of the whitemouth croaker fishing fleet.

Keywords: economic and financial analyses, cost structure, bottom gillnet fishery, fisheries management, southern Brazil.

Análisis costo-beneficio de tres pesquerías de enmalle en Santa Catarina, Brasil: contribuyendo a las decisiones de manejo pesquero

RESUMEN. El análisis de costo-beneficio de las tres pesquerías industriales de enmalle de fondo que operaron en el SE/S Brasil durante 2009 tuvo un doble propósito: determinar el desempeño económico y financiero de una embarcación promedio que opera con enmalle en las pesquerías de corvina (*Micropogonias furnieri*), brótula (*Urophycis mystacea)* y rape (*Lophius gastrophysus*) y establecer los efectos que se pueden esperar al aplicar la regulación al arte de pesca (MPA/MMA Nº12/2012) en el desempeño de la flota que pesca la corvina. Crucial para este análisis de costo-beneficio fue la recolección de información mediante entrevistas a dueños de embarcaciones sobre las estructuras y los niveles de costos en la pesca. Tres indicadores de desempeño económico y financiero fueron utilizados para evaluar la condición en que se encuentran estas flotas pesqueras: Valor Presente Neto (VPN), Tasa Interna de Retorno (TIR) e Índice de Rentabilidad (IR). Los resultados mostraron diferentes niveles de costos entre las flotas pesqueras. Sin embargo, presentan similar importancia relativa los componentes de costos entre flotas: los costos corrientes son los mayores, seguidos en orden de importancia por los costos de operación de la embarcación y del trabajo, excepto en la flota pesquera de brótula. Los resultados de la evaluación del desempeño económico y financiero mostraron que estas tres flotas estaban en condición económica y financiera frágil, teniendo TIRs menores de 20% e IRs de 1,7 o menores, lo que es muy bajo para actividades de alto riesgo como es la pesca. Este problema resultó más agudo en la flota pesquera de corvina, que mostraron los menores valores de TIR (12,11%) e IR (1,2). Los efectos potenciales de aplicar la regulación al arte de pesca mostraron mejoras marginales en la frágil condición de la flota pesquera de corvina.

Palabras clave: análisis económico y financiero, estructura de costos, pesquería de enmalle de fondo, manejo pesquero, sur de Brasil.

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INTRODUCTION

Among the several industrial fishing fleets operating in the Southeast/South (SE/S) region of Brazil, the bottom gillnet fleet is one of the most important, either in terms of number of vessels as in annual landings. Gillnets have been used by artisanal fishing in the region for many years, while industrial gillnetting was only introduced in Southern Brazil in the late 1980s after the conversion of some bottom trawlers to gillnet vessels (Barcellos *et al.*, 1991; Haimovici, 1997). The fishery developed focusing primarily on demersal fish as angel-shark (*Squatina* spp.), whitemouth croaker (*Micropogonias furnieri*) and Argentine croaker (*Umbrina conosai*), exploited over coastal areas and continental shelf fishing grounds (Pio *et al*., 2012). During the last decade, however, the fishery diversified its target species and expanded its effort to deeper waters in search for more profitable resources (Perez *et al*., 2003). In fact, after 2000, the monkfish (*Lophius gastrophysus*) started to be harvested along slope grounds by Spanish gillnet vessels chartered by Brazilian companies (Perez *et al*., 2002, 2003), using catch and processing technologies previously unknown by the national fleet (Perez *et al*., 2002; Wahrlich *et al*., 2004).

The State of Santa Catarina concentrates a significant part of the industrial fishing fleet operating in SE/S Brazil, including nearly 140 bottom gillnetters whose operational characteristics are not uniform (Pio *et al*., 2012, 2016). Part of the fleet operate on the continental shelf and can be divided in two different fleets, according to their respective target species (*i.e.*, sciaenid fish like Argentine croaker and whitemouth croaker) and mesh sizes (*i.e.*, 100 and 130 mm, respectively). The other two fleets exploit slope resources as the gulf hake (*Urophysis mystacea*) and monkfish using nets of 110 and 280 mm mesh size, respectively (Pio *et al*., 2012, 2016).

Even though these fishing fleets dynamics, their technology and by-catch components are relatively well documented (Perez & Wahrlich, 2005; Pio *et al*. 2012, 2016; Schroeder *et al*., 2014) there is scarce information on these fishing boats costs and their economic and financial performance. Possible reasons for these include the lack of regulations requiring fishermen to provide this kind of information not only in Brazil but, also in most countries of the world (Gasalla *et al*., 2010).

One of the challenges of fisheries science is the integrated analysis of human uses of the marine ecosystem as economic, social and political aspects, and not just the system components that directly affect fish production such as biological and fisheries aspects (Sainsbury & Sumaila, 2001; Dudley, 2008). Lucena & O´Brien (2005) add that economic studies in fisheries are scarce in the world and, as a consequence, management has focused only on biological and technological issues. In spite of the extent of the work done by Tietze *et al*. (2005) on the economic performance and fishing efficiency of marine capture fisheries, at a global scale, data on fishing costs and cost structure are poorly documented, and they vary according to the type of fishery, vessel and fishing gear employed (Lam *et al*., 2011). In such cases, *i.e.*, parametrization models, economic parameters were based only on previous empirical approximations (Gasalla *et al*., 2010). When costs and revenues are known, a series of economic and social analysis can be performed, subsidizing valuable information for developing a more realistic fisheries management (Dreyfus-León & Manzo-Monroy, 1993; Lucena & O´Brien, 2005; Dudley, 2008; Lam *et al*., 2011).

Brazilian reality is not different and during past decades fisheries management has been dominated by biological considerations (Lucena & O´Brien, 2005; Branch *et al*., 2006) while economic, social and political aspects have been neglected, at least on an explicit manner. Management efforts in the bottom gillnet fishery began with the publication of the Normative Instruction (NI) MPA/MMA Nº12/2012 (Brasil, 2012). Even though the main objective of this norm was to reduce incidental catches of small cetaceans, turtles and some elasmobranch species, it also defined a reduction of fishing effort by limiting the maximum extension of gillnets used in the whitemouth croaker fishery whose total length had reached 34 km by the 2000s (Pio *et al*., 2012). The NI defined different maximum net lengths according to the vessels' gross tonnage (GRT) and the area of operation. A gradual reduction in net length over the years was also determined. Even though some aspects of NI MPA/MMA Nº12/2012 focuses in the whitemouth croaker fishery it is in fact, a general norm which applies to all gillnet vessels operating in the SE/S, with the exception of those licensed for monkfish, which are managed according to the NI MMA/SEAP-PR Nº3/2009 (Brasil, 2009).

In this context and based on information collected in year 2009 on landings, fishing effort, costs and revenues for the whitemouth croaker, gulf hake and the monkfish gillnet fishing fleets of Santa Catarina, Brasil, this study had a twofold purpose: first to assess their economic and financial performance under the 2009 conditions and; second to assess the expected effects of applying NI MPA/MMA Nº12/2012 on the economic and financial performance of the representative vessel in the whitemouth croaker gillnet fishery.

MATERIALS AND METHODS

Data

Crucial to the completion of this paper objective was to collect data through interviews to vessel owners on their fishing fleets cost structures, fishing costs levels and others.

Economic data of the bottom gillnet fishing fleet operating in year 2009 was obtained through interviews conducted with vessel owners from Itajaí and Navegantes harbors in Santa Catarina State (Fig. 1), between July and November 2010. Data on fleet landings was obtained from the Industrial Fishing Statistic Program of Santa Catarina, which is conducted by the University of Vale do Itajaí.

Fifteen fishing vessel owners were interviewed to provide physical, operational and economic information on 30 fishing vessels, 28 vessels targeting whitemouth croaker stocks on the continental shelf, 1 vessel targeting the gulf hake and 1 vessel targeting monkfish. Interviewed vessel owners targeting whitemouth croaker represented a 28% of the operating fishing fleet, the vessel owner targeting gulf hake represented 14% of the operating fleet and the vessel owner targeting monkfish was the only vessel operating in this fishery in 2009.

Physical and operational characteristics included: vessel length overall, GRT, haul capacity, main engine power, year of construction, fishing gear (length and mesh size), crew number and composition, and fishing effort (number of trips), among others (Tables 1 and 2). Economic data collected referred to acquisition or implementation costs, maintenance, fuel and other current costs, crew shares, production and income.

Cost data was collected in Brazilian currency or Reals and then they were used and presented in US dollar (US$) base 2009 using an exchange rate of 1 US$ by 1.74 $ (Brazilian Reals).

Cost structures

Cost structures presented in this study were built following the methodology applied by Tietze *et al.* (2005) to study the economic and financial performance of fishing fleets around the world. This methodology was also applied by Cerda *et al.* (2014) to determine the cost structure and levels of industrial and artisanal fishing fleets and fish processing plants in Chile.

Figure 2 depicts the components of total fishing costs organized according to the categories used by Tietze *et al.* (2005), namely Operating costs (aggregated as Running costs, Vessel costs, and Labor costs) and Other costs.

Running costs refer to all expenditures directly related to the level of fishing effort. Vessel costs refer to maintenance costs related to the ship, including its equipment and the fishing gear, and to insurance costs. Labor costs includes all payments to crew considering the different categories according to each fishery. Labor cost were valued at their opportunity cost considering the potential income a Deck hand may earn in an alternative activity, such as housing construction, which was estimated to be a 1,000 B$/month. Income to other crew members were estimated based on the shares of the share system used in these fishing fleets (Table 3) and the base value for a Deck hand.

Investment costs were collected from the three gillnet fisheries under analysis and they are presented in Tables 4 and 5.

Data collected on fishing costs for the whitemouth croaker fishery are presented in Table 6, along with estimated averages for each cost item, considering a 95% confidence interval. Table 7 presents averages for the gulf hake and the monkfish fisheries in 2009.

Depreciation costs (US$ yr^{-1}) were estimated applying a linear depreciation method for the average representative vessel in each fishery, considering the main components of fishing vessel investment costs (fixed assets) and an estimate of their service life (Table 8).

Economic and financial performance

The analysis of the economic and financial performance of the average representative vessel from each of the three gillnet fisheries considered was based on the traditional economic and financial analysis whose backbone is a cash-flow table summarizing in essence expenditures, revenues and profits over a time period (Mishan, 1978; Sapag & Sapag, 2008). Expenditures considered are investment costs, operational costs and other costs. The period to be considered is named the assessment horizon and it usually covers the lifespan of the project or business under analysis. Revenues are determined by the interaction between the level of production-sales (annual landings) and product market prices (ex-vessel prices) (Table 9). Other revenues obtained from selling assets at market price once either their service life is reached or the assessment horizon has been attained, are also considered. Business profit taxes, interest rates and discount rates are also used to build the cash-flow tables.

Three indicators of performance were used, namely the Net Present Value (NPV), Internal Rate of Return (IRR) and Profitability Index (PI). The assessment horizon considered in this study is of 20 years, corresponding to the service life of the vessel. The dis-

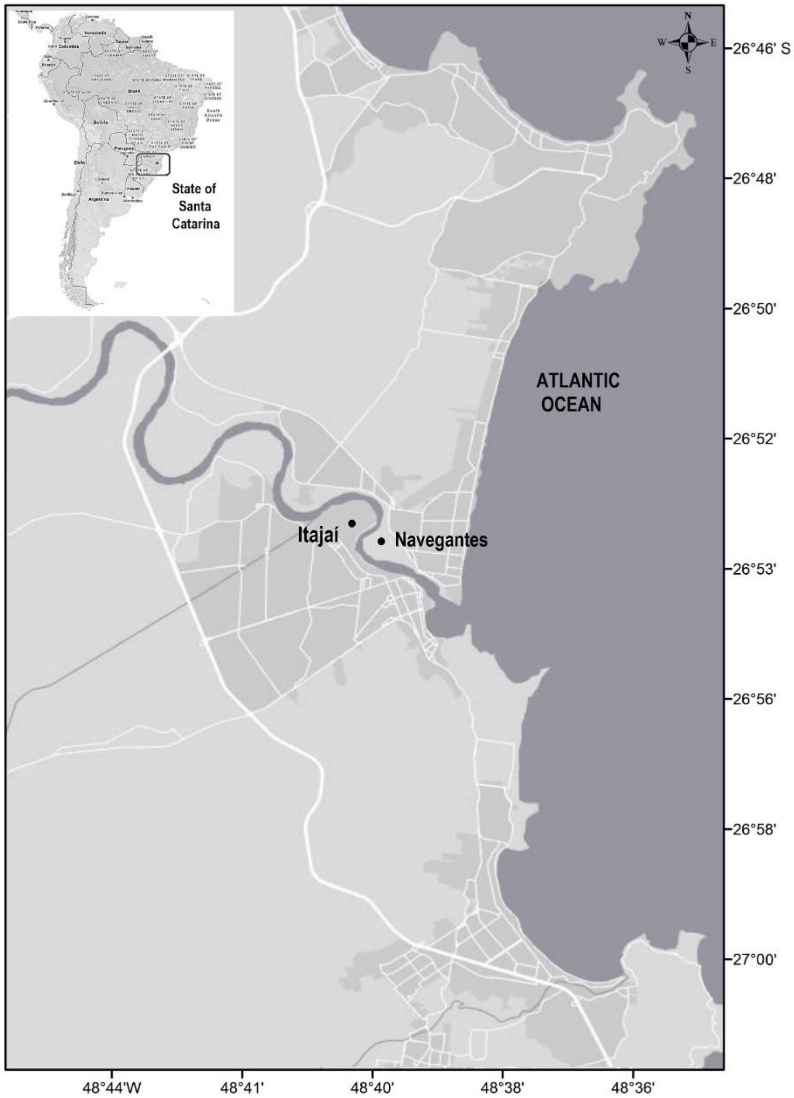


Figure 1. Location of the main fish landing ports of Itajaí and Navegantes, Santa Catarina State, Brazil.

count rate used is of 10% annual, it refers to the rate the Central Bank of Brazil charges to all commercial banks.

NPV is a scalar value expressed in US$ and it is calculated as the difference of the sum of all net cash flows obtained from the first period to the last period of the assessment horizon and the total investment cost realized in period zero or the present (Mishan, 1978; Sapag & Sapag, 2008).

IRR on an investment or project is the "annualized effective compounded return rate" or rate of return that makes the net present value of all cash flows (both positive and negative) from a particular investment equal to zero. It is also defined as the discount rate at which the present value of all future cash flow is equal to the initial investment or, in other words, the rate at which an investment breaks even (Mishan, 1978; Sapag & Sapag, 2008).

PI is also known as profit investment ratio (PIR) or as value investment ratio (VIR) and is the ratio of payoff to investment of a proposed project. It is calculated as the rate between discounted summation of all cash flows from the first to the last period of the project assessment and the amount of investment costs realized of the current or zero period. Thus, it is a useful tool for ranking projects because it allows you to quantify the amount of value created per unit of investment cost (Mishan, 1978; Sapag & Sapag, 2008).

Expected effects of the fishing gear regulation in the whitemouth croaker fishery

The above methodology of the analysis of the economic and financial performance of the average representative vessel was applied to estimate the expected effects of the regulation on fishing gear and the same three indi-

Table 1. Main attributes of the whitemouth croaker fishing fleet of Santa Catarina, Brazil, 2009. Source: Pio (2011) and Pio *et al.* (2012).

Whitemouth croaker fleet	Year built	Hull length (m)	Engine power (hp)	Hull capacity (ton)	GRT (ton)	Crew size	Number of net bodies	Gillnet total length (km)	Mesh size (mm)
Vessel I	2005	21.5	290	40	81	7	420	24.8	120
Vessel II	2003	22.9	360	75	120	7	500	29.5	130
Vessel III	2000	20.0	360	50	60	7	400	23.6	130
Vessel IV	2002	18.0	300	45	53	7	450	26.5	130
Vessel V	1984	24.0	350	50		7	480	28.3	130
Vessel VI	1980	23.0	350	45	83	7	450	26.5	130
Vessel VII	1998	19.0	290	45		7	400	23.6	130
Vessel VIII	2003	21.0	320	50	70	7	400	23.6	130
Vessel IX	1985	16.9	290	30	32	7	400	23.6	120
Vessel X	2005	24.0	360	90	105	9	430	25.4	130
Vessel XI	2005	20.0	360	50	60	7	400	23.6	130
Vessel XII	1984	21.0	270	35	48	7	450	26.5	130
Vessel XIII	1994	21.0	350	50	85	7	480	28.3	130
Vessel XIV	2005	21.5	290	50		7	455	26.8	130
Vessel XV	1985	18.0	260	20	30	6	350	20.6	130
Vessel XVI	1981	23.0	370	60	78	8	550	32.4	130
Vessel XVII	2001	22.0	300	70		7	570	33.6	130
Vessel XVIII	2004	20.0	360	50	60	7	400	23.6	130
Vessel XIX	2002	22.8	290	55		7	400	23.6	130
Vessel XX	2003	22.5	360	65	110	7	450	26.5	130
Vessel XXI	2005	19.0	267	40		7	350	20.6	130
Vessel XXII	2006	14.0	180	12		5	100	5.9	130
Vessel XXIII	2002	21.9	320	60	92	7	500	29.5	130
Vessel XXIV	2004	22.8	290	55		7	400	23.6	130
Vessel XXV	2000	20.5	167	40	65	7	400	23.6	130
Vessel XXVI	1995	21.6	290	50	95	7	500	29.5	130
Vessel XXVII	2004	22.5	360	60	70	7	450	26.5	130
Vessel XXVIII	2002	21.4	360	60	82	7	480	28.3	130
Average		20.9	311	50	74	7	429	25.3	129
Lower limit (Conf. 95%)		20.0	290.8	44.0	62.7	6.8	396.7	23.4	128.3
Upper limit (Conf. 95%)		21.8	331.6	56.2	85.2	7.2	461.5	27.2	130.3
Confidence interval (95%)		0.9	20.4	6.1	11.3	0.2	32.4	1.9	1.0
Coefficient of variation		0.1	0.2	0.3	0.3	0.1	0.2	0.2	0.0

Table 2. Main attributes of the gulf hake and monkfish fishing fleet of Santa Catarina, Brazil 2009. Source: Pio (2011) and Pio *et al.* (2012).

Representative vessel	Year built	Hull length (m)	Engine power (hp)	Hull capacity (ton)	Gross tonnage (m^3)	Crew size	Number of net bodies	Gillnet total length (km)	Mesh size (mm)
Gulf hake	2001	23.0	290	60	84	10	500	22.5	110
Monkfish	2002	20.7	290	50	85	10	1,000	50.0	280

cators were used NPV, IRR and PI. The regulation indicates a 46% reduction in fishing gear size from a 24 km gillnet (for more details see Pio *et al.*, 2012) to a 13 km gillnet. Thus, its assumed that investment cost in fishing gear may be reduced in at least 40%.

This ex-ante analysis was based on three scenarios representing the situation before the enactment of the fishing gear regulation (Current scenario) and the expected situation from the application of the regulations, divided into an Optimistic scenario and a Conservative scenario. Each scenario considers an assess-

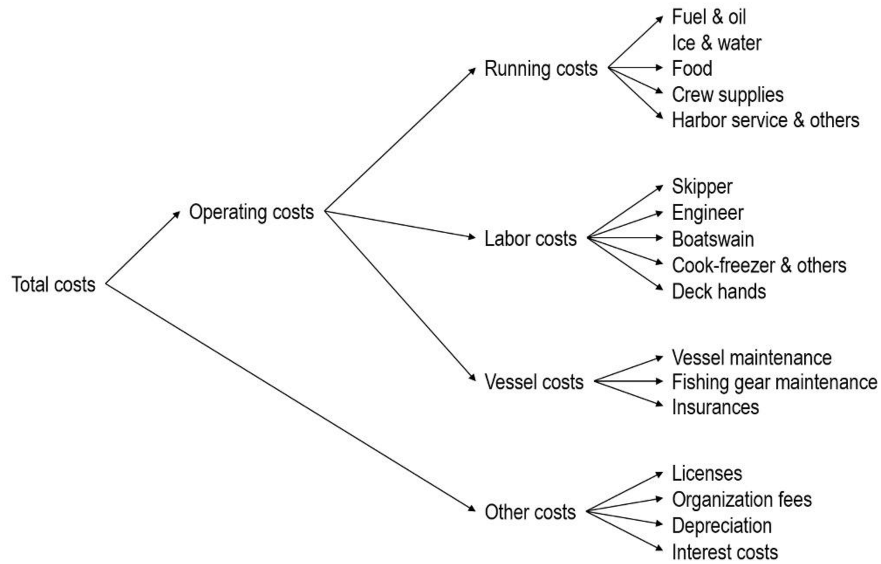


Figure 2. General diagram of fishing costs disaggregation. Source: Tietze *et al.* (2005).

Table 3. Crew shares for three gillnet fisheries, Santa Catarina, Brazil, 2009. Source: Pio (2011).

Crew role	Shares		
	Whitemouth croaker	Gulf hake	Monkfisk
Skipper	3.50	6.00	6.00
Engineer	1.60	4.00	3.50
Boatswain		2.00	2.50
Freezer	1.30	2.00	2.50
Cook	1.30	2.00	2.50
Freezer helper	1.25		2.00
Deck hand 1	1.00	1.50	1.75
Deck hand 2	1.00	1.50	1.75
Deck hand 3		1.50	1.75
Deck hand 4		1.50	1.75
Deck hand 5		1.50	
Total	10.95	23.50	26.00

ment horizon of 20 years, and an annual discount rate of 10% (Central Bank of Brazil).

The Optimistic scenario considers that the implementation of restriction in the length of the gillnet will imply on the one hand, a reduction in the investment costs of 40% in fishing gear. Changes on fishing gear maintenance were not expected as most probably the reduction in materials will be balanced by an increase in the number of net casts per fishing trip. This scenario also includes an estimated 30% reduction in annual harvest during the first year of the assessment horizon, with a 10% recovery in annual harvest until it reaches a maximum of 20% over current annual harvest levels during the seventh year of the assessment horizon. No changes in ex-vessel price are considered.

The Conservative scenario differs in that the maximum expected increase in landings is of 15% and that the expected recovery of annual harvests takes a longer time to occur. That is, it also considers a 30% reduction in annual harvest the first year, followed by a 10% increase in annual harvest reduction years 2 and 3, and a 5% recovery on annual harvest from year 4 on until reaching a 15% increase over current annual harvest levels from year 8 and onward.

RESULTS

Fishing costs and cost structure

Total fishing costs were the highest for the monkfish fishery with a total of approximately US$ 476,000 per year in 2009, followed in importance by the gulf hake fishery with approximately US$ 342,000 per year and the whitemouth croaker fishery with US$ 310,000 per year (Fig. 3). Figure 3 also depicts that Running costs were the most important item among these three fisheries, representing between 42% to 44% of the total costs. Vessel costs were the second most important cost component in the whitemouth croaker fishery (27%) and the monkfish fishery (29%). Labor costs were the second most important cost item in the gulf hake fishery (29%), but they ranked third for the whitemouth croaker and the monkfish fisheries, with a 20% and 22%, respectively. Other costs were the smallest costs ranging from 6% to 9%.

Figure 4 presents the components of Running costs for all three fisheries where monkfish fishery had the largest cost with US$ 210,000 per year, followed by

Table 4. Investment costs (thousand US$) in the whitemouth fishing fleet, Santa Catarina, Brazil, 2009. Source: Pio (2011).

Whitemouth croaker fleet	Hull, engines & others	Deck equipment, hydraulics & lifesaving	Monitoring & navigation	Vessel	Fishing gear
Vessel I	246.0	31.0	19.0	296.0	92.0
Vessel II	437.0	45.0	21.4	503.4	109.0
Vessel III	407.0	43.0	20.7	470.7	103.0
Vessel IV	297.0	46.0	24.1	367.1	103.0
Vessel V	401.0	66.0	16.6	483.6	116.0
Vessel VI	246.0	31.0	19.0	296.0	98.0
Vessel VII	407.0	34.0	17.3	458.3	87.0
Vessel VIII	370.0	46.0	20.0	436.0	92.0
Vessel IX	246.0	31.0	19.0	296.0	87.0
Vessel X	361.0			361.0	
Vessel XI	407.0	43.0	20.7	470.7	103.0
Vessel XII	297.0	46.0	24.7	367.7	103.0
Vessel XIII	401.0	66.0	16.6	483.6	116.0
Vessel XIV					
Vessel XV	370.0	46.0	20.0	436.0	80.0
Vessel XVI	245.0	55.0	19.9	319.9	95.0
Vessel XVII	297.0	46.0	24.7	367.7	131.0
Vessel XVIII	407.0	43.0	20.7	470.7	103.0
Vessel XIX	407.0	34.0	17.3	458.3	87.0
Vessel XX	437.0	45.0	21.4	503.4	98.0
Vessel XXI	293.0	23.0	21.4	337.4	60.0
Vessel XXII	176.0	12.0	2.2	190.2	18.0
Vessel XXIII	361.0			361.0	
Vessel XXIV	407.0	34.0	17.3	458.3	87.0
Vessel XXV	370.0	46.0	20.0	436.0	92.0
Vessel XXVI	369.0	51.0	10.4	430.4	115.0
Vessel XXVII	407.0	43.0	20.7	470.7	116.0
Vessel XXVIII	401.0	66.0	16.6	483.6	116.0
Average	350.7	42.9	18.9	407.9	96.3
Lower limit (Conf. 95%)	322.5	37.6	1.0	376.1	87.2
Upper limit (Conf. 95%)	379.0	48.1	1.0	439.8	105.4
Confidence interval (95%)	28.3	5.3	1.9	31.9	9.1
Coefficient of variation	0.20	0.30	0.24	0.20	0.23

Table 5. Investment costs (thousand US$) in the gulf hake and monkfish fishing fleets, Santa Catarina, Brazil, 2009. Source: Pio (2011).

Representative vessel	Hull, engines & others	Deck equipment, hydraulics & lifesaving	Monitoring & navigation	Vessel	Fishing gear
Gulf hake	384	52	26.0	462	102
Monkfish	356	55	34.3	445	230

gulf hake and whitemouth croaker with US$ 147,000 and US$ 129,000 per year, respectively. Fuel & lubricant was the most important expenditure representing between 52% to 57% of total running costs in 2009. Next item in importance were expenses on Personnel or crew supplies (other than food) and Food which in total ranges from 20% in the whitemouth croaker fishery to 28% in the gulf hake fishery. Ice & water were third in importance representing between 14% to 16% of the Running costs. Harbor services and Navigation & monitoring represented together between 6% to 8% of the running costs in 2009.

Labor costs are depicted in Figure 5 and the gulf hake fisheries incurred in higher expenditures followed by the monkfish and the whitemouth croaker fishery. Payment to officers like the skipper, the engineer (or motormen) and boatswain ranged from 45% to 51% of all crew payment. Payment to simple deck hands ran-

Table 6. Fishing costs (US$ yr^{-1}) for the whitemouth croaker fishery, Santa Catarina, Brazil, 2009. Source: Pio (2011).

Whitemouth croaker fleet	Insurance	Licenses	Organization fees	Harbour services	Navigation & monitoring	Vessel maintenance	Fishing gear maintenance	Crew supplies	Food	Ice	Water	Lubricant	Fuel
Vessel I		330	345	4,055	2,407	33,507	51,724	5,882	22,941	19,853	706	2,471	72,958
Vessel II	5,747	345	345	5,460	1,832	35,920	45,977	8,824	17,647	20,588	1,765	2,471	73,958
Vessel III		517	8,276	14,793	6,499	58,333	72,414	6,353	18,529	18,529	706	6,353	72,149
Vessel IV	8,046	287	862	4,630	6,430	31,034	45,977	4,118	23,529	23,529	588	3,059	73,369
Vessel V		241	2,069	2,115	3,557	55,288	51,724	5,294	20,000	19,118	471	2,471	76,899
Vessel VI		330	345	4,055	2,407	33,507	51,724	5,882	22,941	19,853	706	2,471	72,958
Vessel VII		299	345	4,138	9,304	33,333	34,483	4,706	14,118	20,235	706	2,447	73,981
Vessel VIII		287	690	8,331	3,840	49,885	28,736	5,882	17,647	20,588	588	3,059	73,369
Vessel IX		330	345	4,055	2,407	33,507	51,724	5,882	22,941	19,853	706	2,471	72,958
Vessel X		287	1,034	2,331	6,430	47,989	26,437	11,765	20,588	14,412	412	3,059	85,134
Vessel XI		517	8,276	14,793	6,499	58,333	72,414	6,353	18,529	18,529	706	6,353	72,149
Vessel XII	8,046	287	862	8,078	6,430	31,034	45,977	4,118	18,028	12,386	588	3,040	55,329
Vessel XIII		241	2,069	2,115	3,557	55,288	51,724	5,294	20,000	19,118	471	2,471	76,899
Vessel XIV			793	201	683	20,546	68,966	7,059	18,824	21,176	706	2,118	83,487
Vessel XV		287	690	8,331	3,840	49,885	28,736	5,882	17,647	20,588	588	3,059	43,958
Vessel XVI	6,897	322	1,724	3,193	4,138	19,082	11,494	3,529	20,588	23,529	1,765	2,647	83,193
Vessel XVII	8,046	287	862	4,630	6,430	31,034	45,977	4,118	23,529	23,529	588	3,059	73,369
Vessel XVIII		517	8,276	14,793	6,499	58,333	72,414	6,353	18,529	18,529	706	6,353	72,149
Vessel XIX		362	345	4,138	9,304	25,575	34,483	4,706	14,118	20,235	706	2,447	61,805
Vessel XX		345	345	5,460	1,832	35,920	45,977	8,824	17,647	20,588	1,765	2,471	73,958
Vessel XXI	2,069	345		862	1,327	20,230	25,862	5,294	13,235	16,941	529	2,753	66,722
Vessel XXII	414	270				2,299	5,747	11,765	20,588	14,412	412	824	22,664
Vessel XXIII		287	1,034	2,331	6,430	47,989	26,437	11,765	20,588	14,412	412	3,059	79,294
Vessel XXIV		362	345	4,138	9,304	33,333	34,483	4,706	14,118	20,235	706	2,447	61,805
Vessel XXV		287	690	8,331	3,840	49,885	28,736	5,882	17,647	20,588	588	3,059	73,369
Vessel XXVI		316		4,397	1,832	30,172	57,471	2,353	20,588	11,765	588	2,647	91,471
Vessel XXVII		517	8,276	14,793	6,499	58,333	72,414	6,353	18,529	18,529	706	6,353	72,149
Vessel XXVIII		241	2,069	2,115	3,557	55,288	51,724	5,294	20,000	19,118	471	2,471	76,899
Average	1,402	323	1,833	5,595	4,540	39,102	44,356	6,257	19,058	18,956	727	3,142	71,014
Lower limit (Conf, 95%)	285	283	769	3,877	3,519	33,386	37,337	5,300	17,954	17,776	579	2,596	65,919
Upper limit (Conf, 95%)	2,520	363	2,896	7,313	5,561	44,818	51,374	7,214	20,162	20,136	874	3,687	76,110
Confidence interval (95%)	1,117	40	1,064	1,718	1,021	5,716	7,018	957	1,104	1,180	147	545	5,096
Coefficient of variation	2.050	0.32	1.500	0.790	0.580	0.380	0.410	0.460	0.160	0.170	0.66	0.540	0.200

Table 7. Fishing costs (US\$ yr^{-1}) for the gulf hake and monkfish fishery, Santa Catarina, Brazil, 2009. Source: Pio (2011).

Representative vessel	Insurance	Licenses	Organization fees	Harbour services	Navigation & monitoring	Vessel maintenance	Fishing gear maintenance	Crew supplies	Food	Ice	Water	Lubricant	Fuel
Gulf hake		287	345	2,873	3,557	9,484	57,471	5,882	35,294	23,529		3,059	72,958
Monkfish	8,966	345	345	4,379	9,304	61,207	69,540	10,588	41,176	29,412	706	6,471	108,082

ged from 18% to 32% of all labor costs depending on the number crew considered. All remaining payments were allotted to intermediate posts like Cook, Freezer men or Freeze helper.

Vessel costs (Fig. 6) and the monkfish fishery incurred in the higher expenditure in this item with approximately US$ 140,000 per year in 2009, followed by the representative vessel of the Whitemouth croaker fishery and that of the gulf hake fishery with US$ 85,000 and US$ 67,000 per year, respectively.

Figure 7 presents the item Other costs, including fishing licenses, organizational fees and assets depreciation (Table 8). Again the monkfish and the gulf hake fisheries incurred in higher levels of expenditure with approximately US$ 30,000 to 31,000 per year, followed by the whitemouth croaker fishery with approximately US$ 26,000 spent in 2009. Licenses and organizational fees were marginal while, depreciation represented between 92% and 98% of this item.

Investment cost

Investment costs were separated into Vessel cost and Fishing gear cost (Tables 4 and 5). Investment on Vessel assets in the whitemouth croaker fishery was estimated to be an average of US$ 407,900 with a confidence interval (95%) of US$ 31,900 (Table 4).

The main component of this investment was “Hull, engines & others”, representing an 86% of total vessel investment, followed by “Deck Equipment, hydraulics & lifesaving” with a 10.5% of the total and “Monitoring & Navigation” with a 4.6% of the total. In this same fishery investment on “Fishing gear” was estimated to be an average of US$ 96,300 with a confidence interval (95%) of US$ 9,100 (Table 4).

The main characteristics for this average vessel in the whitemouth croaker fishery were estimate as: 21 m of length overall, a main engine of 290 HP, a hull capacity of 60 ton, a GRT of 70 ton, 7 crew members, a gillnet of 429 bodies and 25 km long and a mesh size of approximately 130 mm (Table 1).

Investment on Vessel assets in the gulf hake and the monkfish fisheries were estimated to be an average of US$ 462,000 and US$ 445,000, respectively as of 2009 (Table 5). The main component of these investments were “Hull, engines & others”, representing an 80% to 83% of total vessel investment, followed by “Deck equipment, hydraulics & lifesaving” with 11% to 12% of the total and “Monitoring & navigation” with 6% to 8% of the total.

Investment on “Fishing gear” was estimated to be an average of US$ 102,000 for the gulf hake fishery and of US$ 230,000 for the monkfish fishery in 2009 (Table 5). The main characteristics for these average vessels are presented in Table 2.

Table 8. Depreciation costs for three gillnet fisheries in Santa Catarina, Brazil, 2009. Source: Pio (2011). http://smallbusiness.chron.com/tax-issues-company-fishing-boats-80960.html, http://www.sii.cl/pagina/valores/bienes/tabla_vida_enero.htm, http://www.windom.org/de-preciationfishing.html.

Representative vessel	Hull, engines & others	Deck equipment, hydraulics & lifesaving	Monitoring & navigation	Vessel
Investment costs (thousand US$)				
Whitemouth croaker fleet	350.7	42.9	18.9	412.5
Gulf hake	384.0	52.0	26.0	462.0
Monkfish	356.0	55.0	34.3	445.3
Service life (years)	20	10	5	
Depreciation (US$ yr^{-1})				
Whitemouth croaker fleet	17,537	4,288	3,774	25,599
Gulf hake	19,200	5,200	5,200	29,600
Monkfish	17,800	5,500	6,860	30,160

Table 9. Annual landings (kg yr^{-1}) and ex-vessel price (US$ kg^{-1}) for three gillnet fisheries in Santa Catarina, Brazil, 2009. Source: Pio (2011).

Representative vessel	Landings (kg yr^{-1})	Ex-vessel price (US$ kg^{-1})
Whitemouth croaker	200,000	1.84
Gulf hake	250,000	1.61
Monkfish	280,000	2.01

Economic and financial performance of the representative vessels

Figure 8 presents the level reached by the NPV, the IRR and the PI for the average vessel in the three fisheries studied under current conditions and Tables 10, 11 and 12 present the cash flow used to calculate these indicators. These indicators showed that all three average fishing vessels are generating profits over time. Please notice total vessel investment cost for whitemouth croaker average vessel is marginally higher in Tables 8 and 10, as it corresponds to the summation of the averages for the three investment components (*i.e.*, "Hull, engines & others", "Deck equipment, hydraulics & lifesaving" and "Monitoring & navigation") and not the average of that summation for all vessels in the fleet (Table 4).

For a period of 20 years the average vessel in whitemouth croaker fishery generated the US$ 82,785, with an IRR of 12.1% annual and a PI of 1.2 US$ on each US$ invested in 20 years. In a similar time horizon, the average vessel in gulf hake fishery generated an NPV of US$ 176,641, an IRR of 14.1% and a PI of 1.3 US$ on each US$ invested (Table 11). In turn, the average vessel in the monkfish fishery generated an NPV of US$ 501,568, an IRR of 19.5% and a PI of 1.7 US$ on each US$ invested (Table 12).

Expected effects of the fishing gear regulation in the whitemouth croaker fishery

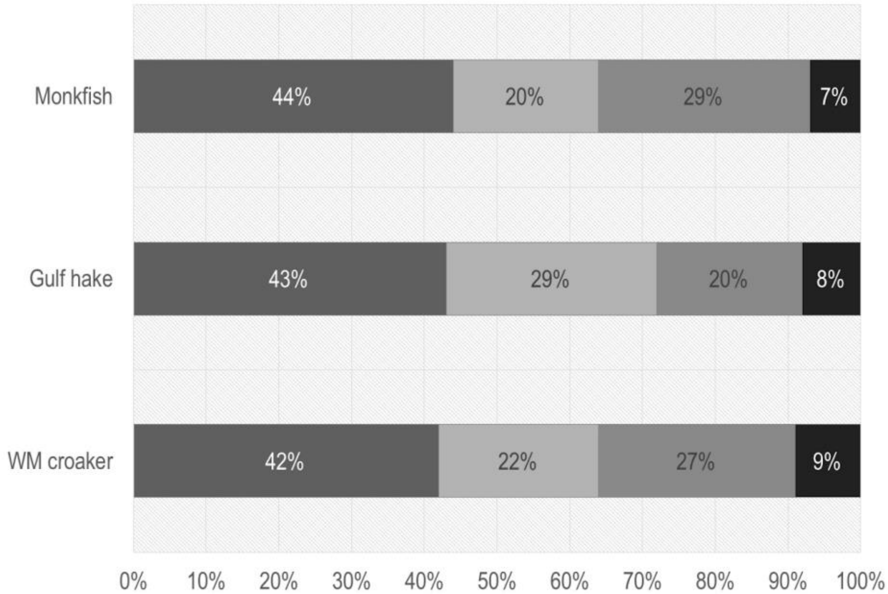
The above presented information on fishing vessel and gear investment costs, fishing costs, landings and revenues were used to analyze the expected effects of applying the regulation on fishing gear in the whitemouth croaker fishery. Figure 9 presents the effects on the economic and financial performance of the average vessel in the whitemouth croaker fishery of the regulation on the fishing gear according to the three scenarios considered, namely: Current conditions, Optimist and Conservative.

As Figure 9 the expected effects on the average vessel from the Optimist scenario were to provide a 219% increase in NPV, a 23% increase in the IRR and a 34% increase in PI. Similarly, the expected effects from the Conservative scenario are also positive but lower levels of increase in the indicators used, thus, Figure 9 shows a lower increase of 60% in NPV, a marginal increase of 2% in IRR and small increase of 10% in PI.

DISCUSSION

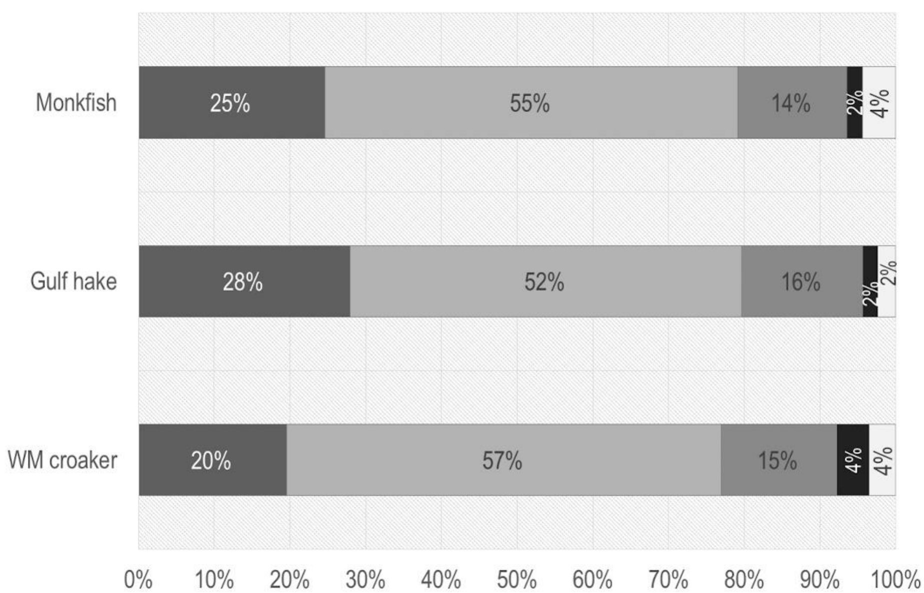
With respect to the fishing costs structures results obtained for the average vessel in these three fisheries were similar to those obtained by Tietze *et al.* (2005) for gillnet fishing boats in Senegal and those obtained by Cerda *et al*. (2014) gillnet fishing boat in central south Chile, where the weight of fishing costs is on Running, labor and vessel costs. The relative lower weight estimated for these costs items when compared to those estimated by the above mentioned authors, arises from the fact that our costs structure includes Other costs but, theirs did not included such costs.

Results obtained for the gulf hake and monkfish fishery are comparable to those obtained by Tietze *et*



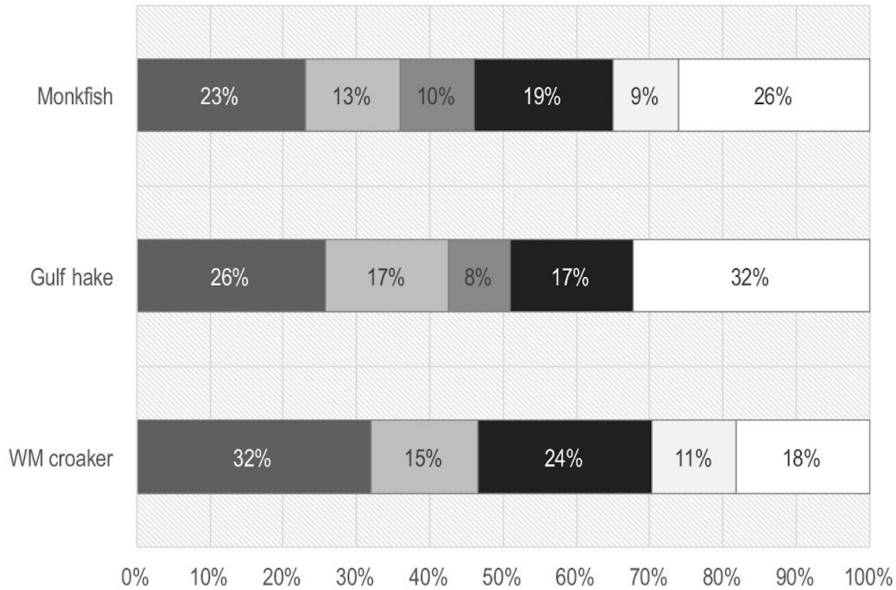
US$ yr-1 (2009)	WM croaker	Gulf hake	Monkfish
Running costs	129,288	147,152	210,118
Labor	69,224	97,989	95,586
Vessel costs	84,860	66,955	139,713
Other costs	26,264	30,232	30,850

Figure 3. Total fishing costs (US$) and cost structure for three gillnet fisheries of Santa Catarina, Brazil, 2009.



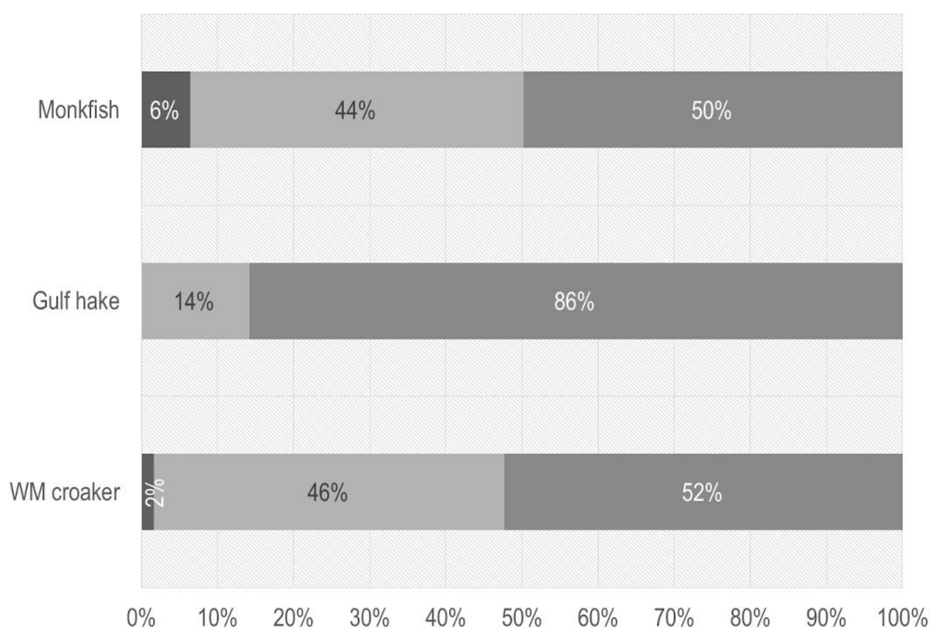
US$ yr-1 (2009)	WM croaker	Gulf hake	Monkfish
Pers. supply & food	25,315	41,176	51,764
Fuel & lubricant	74,156	76,017	114,553
Ice & water	19,683	23,529	30,118
Harbour services	5,595	2,873	4,379
Navigation & monitoring	4,540	3,557	9,304

Figure 4. Running costs (US$ yr^{-1}) and cost structure for three gillnet fisheries of Santa Catarina, Brazil, 2009.



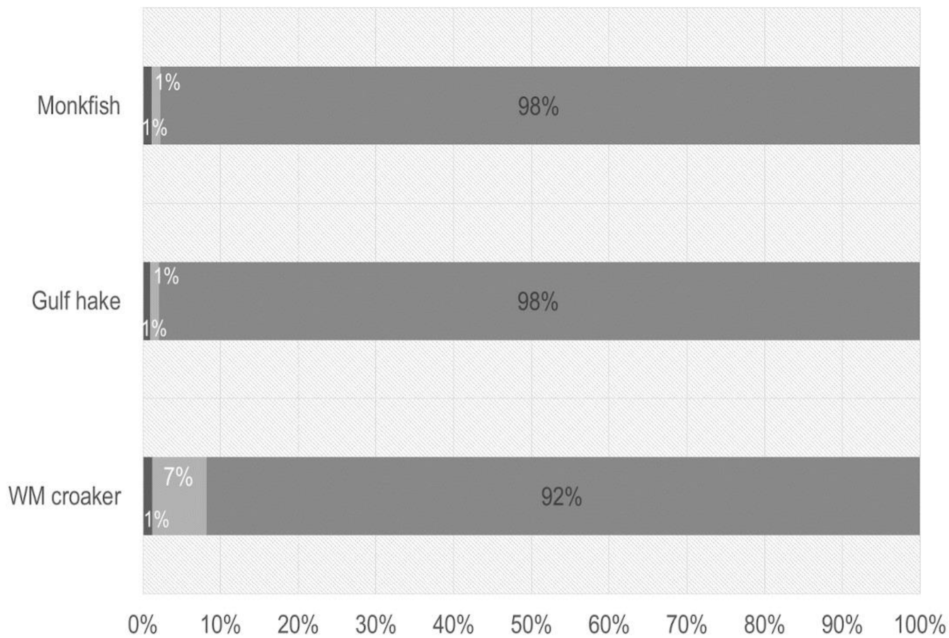
US$ yr^{-1} (2009)	WM croaker	Gulf hake	Monkfish
Skipper	22,126	25,287	21,684
Engineer	10,115	16,437	12,644
Boatswain		8,218	9,040
Cook/Freezer	16,437	16,437	18,080
Freeze helper	7,902		8,851
Deck hand	12,644	31,609	25,287

Figure 5. Labor costs (US$ yr^{-1}) and cost structure for three gillnet fisheries of Santa Catarina, Brazil, 2009.



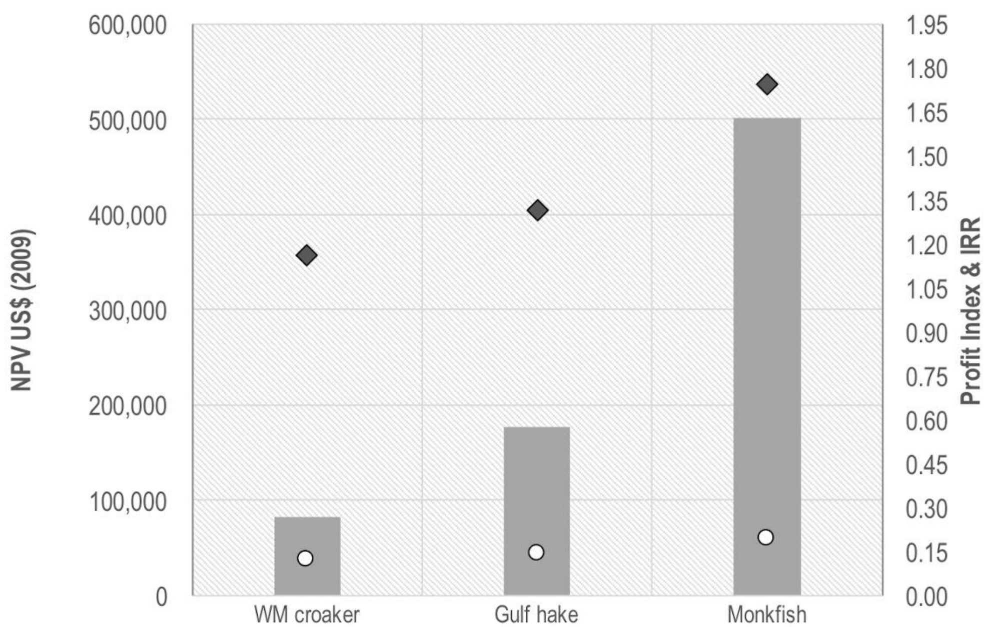
US$ yr^{-1} (2009)	WM croaker	Gulf hake	Monkfish
Insurance	1,402		8,966
Vessel maintenance	39,102	9,484	61,207
Fishing gear maintenance	44,356	57,471	69,540

Figure 6. Vessel costs (US$ yr^{-1}) and cost structure for three gillnet fisheries of Santa Catarina, Brazil, 2009.



US$ yr^{-1} (2009)	WM croaker	Gulf hake	Monkfish
Licenses	323	287	345
Organization fees	1,833	345	345
Depreciation	24,109	29,600	30,160

Figure 7. Other costs (US$ yr^{-1}) and cost structure for three gillnet fisheries of Santa Catarina, Brazil, 2009.



	WM croaker	Gulf hake	Monkfish
NPV (US$ 2009)	82,785	176,641	501,568
IRR	0.1211	0.1409	0.1951
Profit Index	1.2	1.3	1.7

Figure 8. Indicators of economic and financial performance for the representative vessel in three gillnet fisheries of Santa Catarina, Brazil, 2009.

Table 10. Cash-flow for the average vessel in the whitemouth croaker fishery of Santa Catarina, Brazil, 2009.

	Year																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOTAL REVENUES		368,000	368,000	368,000	368,000	368,943	368,000	368,000	368,000	368,000	371,087	368,000	368,000	368,000	368,000	368,943	368,000	368,000	368,000	368,000	371,087
Fishing revenues		368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000	368,000
Annual harvest (ton)		200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Ex-vessel price (US$ kg^{-1})		1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84
Other revenues						943					3,087					943					3,087
TOTAL COSTS		311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127	311,127
Operating costs		283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373	283,373
Running costs		129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288
Pers. supply & food		25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315
Fuel & lubricant		74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156
Ice & water		19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683
Harbour services		5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595
Navigation & monitoring		4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540
Labor		69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224	69,224
Skipper		22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126	22,126
Engineer		10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115	10,115
Boatswain																					
Cook/freezer (2)		16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437
Freeze helper		7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902	7,902
Deck hand (2)		12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644
Vessel costs		84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860
Insurance		1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402
Vessel maitenance		39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102
Fishing gear maintenance		44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356
Other costs		27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754	27,754
Licenses		323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323	323
Unión		1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833
Depreciation		25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599
Interest cost																					
PROFITS BEFORE TAXES		56,873	56,873	56,873	56,873	57,817	56,873	56,873	56,873	56,873	59,961	56,873	56,873	56,873	56,873	57,817	56,873	56,873	56,873	56,873	59,961
TAXES ON PROFITS (15%)		8,531	8,531	8,531	8,531	8,672	8,531	8,531	8,531	8,531	8,994	8,531	8,531	8,531	8,531	8,672	8,531	8,531	8,531	8,531	8,994
PROFITS AFTER TAXES		48,342	48,342	48,342	48,342	49,144	48,342	48,342	48,342	48,342	50,967	48,342	48,342	48,342	48,342	49,144	48,342	48,342	48,342	48,342	50,967
Depreciation		25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599	25,599
INVESTMENT	508,769	0	0	0	0	18,868	0	0	0	0	61,748	0	0	0	0	18,868	0	0	0	0	0
Vessel	412,489	0	0	0	0	18,868	0	0	0	0	61,748	0	0	0	0	18,868	0	0	0	0	0
Hull, engines & others	350,741																				
Deck equip., hydraul. & lifesaving	42,880										42,880										
Monitoring & navigation	18,868					18,868					18,868					18,868					
Fishing gear	96,280																				
NET CASH FLOW	-508,769	73,941	73,941	73,941	73,941	55,875	73,941	73,941	73,941	73,941	14,817	73,941	73,941	73,941	73,941	55,875	73,941	73,941	73,941	73,941	76,565
Discounted net cash flow	-508,769	67,219	61,108	55,553	50,503	34,694	41,738	37,943	34,494	31,358	5,713	25,916	23,560	21,418	19,471	13,376	16,092	14,629	13,299	12,090	11,381
NET PRESENT VALUE	82,785																				
IRR	12.1%																				
PROFIT INDEX	1.2																				

Table 11. Cash-flow for the average vessel in the gulf hake fishery of Santa Catarina, Brazil, 2009.

	Year																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOTAL REVENUES		402,500	402,500	402,500	402,500	403,800	402,500	402,500	402,500	402,500	406,400	402,500	402,500	402,500	402,500	403,800	402,500	402,500	402,500	402,500	406,400
Fishing revenues		402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500	402,500
Annual harvest (ton)		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Ex-vessel price (US$ kg^{-1})		1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
Other revenues						1,300					3,900					1,300					3,900
TOTAL COSTS		342,328	342,328	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464	324,464
Operating costs		312,096	312,096	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232	294,232
Running costs		147,152	147,152	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288	129,288
Pers. supply & food		41,176	41,176	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315	25,315
Fuel & lubricant		76,017	76,017	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156	74,156
Ice & water		23,529	23,529	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683	19,683
Harbour services		2,873	2,873	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595	5,595
Navigation & monitoring		3,557	3,557	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540	4,540
Labor		97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989	97,989
Skipper		25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287
Engineer		16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437
Boatswain		8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218	8,218
Cook/freezer (2)		16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437	16,437
Freeze helper		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deck hand (2)		31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609	31,609
Vessel costs		66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955	66,955
Insurance		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vessel maitenance		9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484	9,484
Fishing gear maintenance		57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471	57,471
Other costs		30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232	30,232
Licenses		287	287	287	287	287	287	287	287	287	287	287	287	287	287	287	287	287	287	287	287
Unión		345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345
Depreciation		29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600
Interest cost																					
PROFITS BEFORE TAXES		60,172	60,172	78,036	78,036	79,336	78,036	78,036	78,036	78,036	81,936	78,036	78,036	78,036	78,036	79,336	78,036	78,036	78,036	78,036	81,936
TAXES ON PROFITS (15%)		9,026	9,026	11,705	11,705	11,900	11,705	11,705	11,705	11,705	12,290	11,705	11,705	11,705	11,705	11,900	11,705	11,705	11,705	11,705	12,290
PROFITS AFTER TAXES		51,147	51,147	66,331	66,331	67,436	66,331	66,331	66,331	66,331	69,646	66,331	66,331	66,331	66,331	67,436	66,331	66,331	66,331	66,331	69,646
Depreciation		29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600	29,600
INVESTMENT	564,000	0	0	0	0	26,000	0	0	0	0	78,000	0	0	0	0	26,000	0	0	0	0	0
Vessel	462,000	0	0	0	0	26,000	0	0	0	0	78,000	0	0	0	0	26,000	0	0	0	0	0
Hull, engines & others	384,000																				
Deck equip., hidraul. & lifesaving	52,000										52,000										
Monitoring & navigation	26,000					26,000					26,000					26,000					
Fishing gear	102,000																				
NET CASH FLOW	-564,000	80,747	80,747	95,931	95,931	71,036	95,931	95,931	95,931	95,931	21,246	95,931	95,931	95,931	95,931	71,036	95,931	95,931	95,931	95,931	99,246
Discounted net cash flow	-564,000	73,406	66,733	72,074	65,522	44,108	54,150	49,228	44,752	40,684	8,191	33,623	30,566	27,788	25,262	17,005	20,877	18,979	17,254	15,685	14,752
NET PRESENT VALUE	176,641																				
IRR	14.1%																				
PROFIT INDEX	1.3																				

Table 12. Cash-flow for the average vessel in the monkfish fishery of Santa Catarina, Brazil, 2009.

	Year																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOTAL REVENUES		562,800	562,800	562,800	562,800	564,515	562,800	562,800	562,800	562,800	567,265	562,800	562,800	562,800	562,800	564,515	562,800	562,800	562,800	562,800	567,265
Fishing revenues		562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800	562,800
Annual harvest (ton)		280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280
Ex-vessel price (US$ kg^{-1})		2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
Other revenues						1,715					4,465					1,715					4,465
TOTAL COSTS		476,267	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414	421,414
Operating costs		445,417	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564	390,564
Running costs		210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118	210,118
Pers. supply & food		51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764	51,764
Fuel & lubricant		114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553	114,553
Ice & water		30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118	30,118
Harbour services		4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379	4,379
Navigation & monitoring		9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304	9,304
Labor		95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586	95,586
Skipper		21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684
Engineer		12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644	12,644
Boatswain		9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040
Cook/freezer (2)		18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080	18,080
Freeze helper		8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851	8,851
Deck hand (2)		25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287	25,287
Vessel costs		139,713	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860	84,860
Insurance		8,966	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402
Vessel maitenance		61,207	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102	39,102
Fishing gear maintenance		69,540	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356	44,356
Other costs		30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850	30,850
Licenses		345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345
Unión		345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345
Depreciation		30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160
Interest cost																					
PROFITS BEFORE TAXES		86,533	141,386	141,386	141,386	143,101	141,386	141,386	141,386	141,386	145,851	141,386	141,386	141,386	141,386	143,101	141,386	141,386	141,386	141,386	145,851
TAXES ON PROFITS (15%)		12,980	21,208	21,208	21,208	21,465	21,208	21,208	21,208	21,208	21,878	21,208	21,208	21,208	21,208	21,465	21,208	21,208	21,208	21,208	21,878
PROFITS AFTER TAXES		73,553	120,178	120,178	120,178	121,636	120,178	120,178	120,178	120,178	123,973	120,178	120,178	120,178	120,178	121,636	120,178	120,178	120,178	120,178	123,973
Depreciation		30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160	30,160
INVESTMENT	675,300	0	0	0	0	34,300	0	0	0	0	89,300	0	0	0	0	34,300	0	0	0	0	0
Vessel	445,300	0	0	0	0	34,300	0	0	0	0	89,300	0	0	0	0	34,300	0	0	0	0	0
Hull, engines & others	356,000																				
Deck equip., hydraul. & lifesaving	55,000										55,000										
Monitoring & navigation	34,300					34,300					34,300					34,300					
Fishing gear	230,000																				
NET CASH FLOW	-675,300	103,713	150,338	150,338	150,338	117,496	150,338	150,338	150,338	150,338	64,833	150,338	150,338	150,338	150,338	117,496	150,338	150,338	150,338	150,338	154,133
Discounted net cash flow	-675,300	94,284	124,246	112,951	102,683	72,956	84,862	77,147	70,134	63,758	24,996	52,692	47,902	43,548	39,589	28,128	32,718	29,744	27,040	24,581	22,911
NET PRESENT VALUE	501,568																				
IRR	19.5%																				
PROFIT INDEX	1.7																				

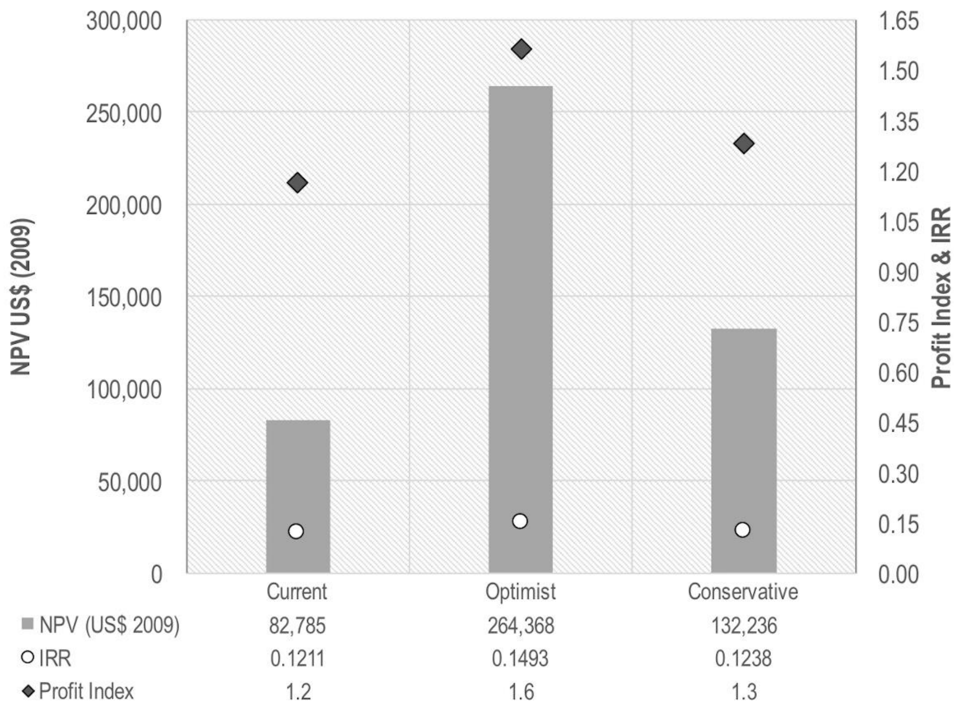


Figure 9. Indicators of economic and financial performance for the average vessel in whitemouth croaker fishery under three management scenario.

al. (2005) for trawler fisheries in South Africa. The differences in the level of fishing costs observed between the whitemouth croaker, gulf hake and monkfish fishery lays on the existing differences on vessel, crew and fishing gear sizes. Other differences in costs, arises from the fact that no vessel pays for insurance in the gulf hake fishery and their vessel maintenance costs are the lowest of the three fisheries.

Vessel owners reported that the preferred fishing gear strategy is to replace sections rather than mend them. In average, vessels operating in the whitemouth croaker fishery replace a lower number of sections per fishing trip than those operating in the gulf hake and monkfish fishery. This may be due to the fact that the whitemouth croaker fishery is conducted on the continental shelf and the gulf hake and monkfish fisheries on the slope.

In general, fuel was determined to be the main cost component in all three fisheries under analysis. According to Sumaila *et al.* (2008) fuel is a substantial component in the cost of fisheries and the proportion varies with each type of fishing, ranging from 60% of the costs as in commercial fishing in Hong Kong. Results for this study showed that Fuel & lubricant ranged from 52% to 57% of the vessels' Running costs what is consistent with the 23% of the total operating costs reported for the bottom gillnet fishery of São Paulo State (Gasalla *et al.*, 2010) and with previous estimations that fuel represents between 10 and 60% of the total cost of the fishing activity in Brazil (Haimovici *et al*., 2006).

When comparing the bottom gillnet fishing, which operates passively during the fishing operation, with an active fishing such as trawling, is evident that bottom gillnet vessels consumes less fuel and therefore have lower operating costs (Lam *et al.*, 2011). In Norway, was reported that trawlers use four times as much fuel to catch one fish ton of fish when compared to local gillnet and line vessels (Smith, 2007).

In summary, fishing costs structure and cost levels obtained in this study showed to be consistent with partial information provided in studies for the Santa Catarina region or others like Alves *et al.* (2009), Gasalla *et al.* (2010), Pio *et al.* (2012), Wahrlich *et al.* (2004) and Piniella *et al.* (2007).

The determination of fishing cost structures and estimation of fishing costs levels are important information to determine in turn the economic and financial performance of the fishing vessels operating the fisheries and this in turn is an important information for fisheries management purposes (Gasalla *et al.*, 2010).

Even though results on NPV, IRR and PI for the average vessel in the three fisheries analyzed showed positive levels, the profitability of the business is low having an IRR lower than 20% and a PI lower than 2, considering a 10% discount rate. The profitability index obtained indicated a return of 70 cents on the dollar for monkfish and of 30 and 20 cents on the dollar for gulf hake and whitemouth croaker fishing vessels which is low compared to US$ 5 or more on the dollar from salmon aquaculture (González *et al.,* 2013). The average vessel takes almost 14 years to recover the capital investment in the whitemouth croaker fishery. In turn it would take approximately 8 and 12 years to recover the capital invested in the gulf hake and monkfish fisheries. According to these results, the whitemouth croaker and the gulf hake fisheries would specially be in a fragile condition.

Most common economic activities like bakeries, shoe stores, small markets have IRR that in average range from 15% to 20%, being activities with low levels of uncertainty and risks. High risk activities like fisheries, aquaculture, mining and others require higher and faster returns on investment, with IRR higher than 40% to 50% (Stutely, 2000).

Nonetheless, these results indicate that the fishery is still an economically viable activity, generating employment and income to fishermen.

Tietze *et al.* (2005) showed a number of fishing activities with low return on investment or even negative ones, so these results are not out of the common in the fishing activity around the world at the fleet level.

Important to bear in mind is that Sumaila *et al.* (2008) showed that in year 2000 Brazil allocated an average of 61 million dollars for the subsidy of diesel, and thus the average per gallon was US$0.11. Therefore, the actual operating costs of the three gillnet fisheries analyzed in this study were lower than what was here estimated. Nonetheless, this does not modify the fact that as a business these fisheries are currently in fragile condition. Furthermore, this type of subsidies will hurt the fishing activity in the long run as they artificially sustain higher levels of fishing effort and mortality than those actually supported by the fish stocks under the current market and economic conditions in Santa Catarina.

Another important element to bear in mind when analyzing the results previously presented is that labor costs were estimated at its opportunity costs, based on the potential incomes a deck hand may earn in the construction business, and was not based on the current prevailing share system. Consideration of the opportunity cost of labor was justified on the grounds that it allows to actually have reasonable estimates of the business profitability. This as when using the share system, crew incomes include not only the payment to actual work, but also includes part of the business profitability. The above is explained by the fact that shares are calculated as portions of a net revenue which is normally obtained from subtracting running costs from gross revenues. The number of portions used normally include the crew and their role, plus additional portions or shares for the capital and the vessel owner. Thus, this system tends to distribute business profitability between the crew and the capital owner (Cardoso *et al.*, 2004; Cardoso & Freitas, 2006; Moreno *et al.*, 2009; Cardoso & Haimovici, 2010; Gasalla *et al.*, 2010, among others). Under a share system, the combination of the vessel and owner shares, would be used to pay for Vessel and Other costs items in Tietze's cost structure.

With respect to the analysis of results from the application of the regulation on fishing gear (Fig. 9) shows improvements in the economic and financial indicators for the whitemouth croaker fishery. In proportional terms the changes in NPV are significant with increases of approximately 220% and 60% for scenarios Optimist and Conservative, respectively, when compared to the current situation. The effects on the IRR and PI are less impressing though, with results that failed to revert the fragile economic and financial performance for the average vessel in the fishery.

The above may be explained by the fact even though the reduction on fishing gear investment cost is relevant with a 40% decrease, there are no expected reductions in fishing gear maintenance costs and the expected increase in landings due to fish stock recovery is expected to be of only 20% at most in scenario Optimist and 15% in scenario Conservative.

This as the gillnet fishing fleet is not the only fleet targeting the whitemouth croaker stock, which is also subject to fishing effort and mortality from the trawler fishery in Santa Catarina. Thus, even though the expected effects from the gear regulation are positive, they seem not to be sufficient by themselves to revert the current fragile situation of this fishing fleet and the whitemouth croaker fish stock supporting them.

Finally, the present study has shown how the information on investment costs, fishing costs and their costs structure, along with fishing effort and landings, ex-vessel prices and complementary information on exchange rates, discount rates and service lives is necessary to conduct assessments and analysis of the economic and financial performance of the fishing activity in Santa Catarina, Brazil, and the management instruments devised by the Brazilian fishing authorities.

In this context, this is a good starting point due to the previous void of economic information but, it is also important to recognize that the analysis presented here was not directly linked to the dynamics of the fish stocks, the fishing fleets and fish markets, and, it only presents a partial comparative static analysis. Dynamic bioeconomic modelling is the approach that needs to be considered for future analyses of these fishing activities and their interaction with both the dynamic of the fish resources and the fish product markets.

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