Multivariate Economic Indicators in Prawn Fishing Case Study (Loma Bonita, Oaxaca)

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Abstract

This document presents the elements from which it was possible to know the current status of the socio-economic fabric of fishermen dedicated to the capture of prawns (Macrobrachium acanthurus) in Loma Bonita, Oaxaca. This study aimed to present the necessary information that would provide a basis for the formulation of future development strategies. The chapter is divided into three blocks of content: The first section provides socioeconomic indicators from which it is possible to define the profile of the fishing population. Next, reference is made to human development indicators classified according to quality of housing, basic services and household equipment. Finally, a brief description is given showing the indicators of economic and financial profitability of the activity.

Keywords: fishing, prawn, socioeconomic indicators

1. Introduction

The basic concept of sustainable development implies the satisfaction of present needs without detracting from that of future generations. Currently, it is increasingly more urgent not only the efficient allocation of scarce resources against various alternatives but also that this allocation be done without degrading the natural resources upon which economic activities are established. From this perspective, sustainable development should not be competing with economic development; however, the lack of value given to resources coupled with the lack of information on the development of economic activities greatly hinders the possible compatibility between both (Astier; 2008). Prawn fishing in Loma Bonita, Oaxaca is a relatively new activity; however, since prawn is recognized as a delicacy with high nutritional value and whose capture is limited and temporary, it becomes a food product in great demand, easily distributed in traditional markets and at prices even over four hundred percent the value of products of traditional fishing. All this has resulted in a significant increase in recent years in the population devoted to this resource, fueling the exploitation of this fishery resource in particular.

Against this background, government mechanisms that balance both interests are needed to ensure the sustainability of resources and of the economic fishing activity; however, to make any decisions, especially those that may affect conflicting interests in the fishing community, it is necessary that administrators be equipped with adequate information. When it comes to the exploitation of a natural resource, not only should the indicators that directly analyze the resource be considered but also the revision of the indicators that emerge from the economic and social activity generated by the resource.

In this paper are presented those indicators which are considered most important in prawn fishing in the area of Loma Bonita, Oaxaca.

2. Materials and Methods

This study arises from a general study of prawns which addresses three major axes: the biological aspect, marketing and socioeconomic indicators. Geographically, it is limited to the lower section of the Obispo River and the Virginia Lagoon, which is where prawns are caught, and the area of Loma Bonita for being the place of origin of the fishermen and therefore the place where the product is marketed. In the specific case of this work, we refer to the prawn fisherman and therefore to Loma Bonita. The instrument used to collect data was a direct survey. Since prawn fishing is a relatively new in the area, there are few fishermen dedicated to this activity, for which it was decided to apply a census with which it was possible to obtain information from 32 of the 36 fishermen detected in this season. The surveys were conducted between the months of May and July of 2013.
In May 2007, the Food and Agriculture Organization (FAO) proposed a set of socioeconomic indicators that could be useful in the analysis and management of fisheries. Seven indicators applicable to prawn fishing were selected and adapted for this study. (See Table 1).

Also performed in the present study is the Principal Component Analysis (PCA) proposed by Vázquez *et al* (2000), which can be summarized in the following steps:

a. Determination of the Different Dimensions

Since in this case the intention is to measure quality of living rather than determine poverty rate, three of the seven dimensions proposed by the authors of the method were selected to evaluate the housing in which a fisherman lives: 1) structural aspects, 2) household equipment (furnishing, appliances, etc.),and 3) access to public services (electricity, sewage, water, etc.)

b. Selection of Variables

For the aforementioned dimensions, a set of variables have been chosen that allow for the most accurate assessment of each. For dimension 1, three variables are defined each with 3 categories; for dimension 2, seven elements have been selected; while for dimension 3, three public services are considered which are regarded as most relevant to a home, Arevalo (1999).

c. Quantitative Assessment of Qualitative Variables and Obtainment of Scores for Homes

The basic idea of a quantitative assessment procedure involves replacing the codes that identify the categories of a variable with "optimal" numerical values so that with these it may be possible to highlight important properties of the data for purposes of research; that is, after an operation of this nature, it will be possible to establish an ordering for the objects of study that allows for an explanation of the relationship of the quantified variable with one or more variables of interest, World Bank (2011). It is obvious that the strategy of quantitative assessment should take into account the relationship between variables, and, therefore, the numerical values assigned to the categories will depend on the variables under consideration. In this project, the quantitative assessment was conducted separately for each variable.

d. Construction of Indices for Each Dimension

For each particular dimension, a partial index was made using the Principal Component Analysis (PCA). Each one of these indices is defined as the first principal component, i.e., a linear combination is made from the different quantified variables that determine that dimension by means of a weighting scheme that reflects the relative importance of each of these variables in the component. As a result of this stage, a partial index will be obtained for the *j-th* dimension, which could be defined and symbolized as:

$$I_j = \sum_{k=1}^{n=j} a_{jk} x_{jk}^{(j)} \qquad Ec\ (1)$$

Where $x_{jk}^{(j)}$ for each *k*= 1,..., *n* represents the variables that determine the *j-th* dimension. *D(j)* and a_{jk} denote a weight or relative weightof the *k-th* variable in the index, Fleis (1973).

2.1. Human Development Index

The Human Development Index (HDI) is a summarized measure of key dimensions of human development. It measures the average progress achieved by a country in three basic dimensions of human development: long and healthy life, access to education and decent standard of living (Meixueirio, 2008). The HDI is the geometric mean of normalized indices corresponding to each one of these three dimensions. See a complete elaboration of the method and its justification in Klugman, Rodriguez and Choi (2011). (Table 2)

The HDI is calculated in two steps:

Step1. Develop indices of each dimension. Minimum and maximum values (threshold values) must be determined in order to transform the indicators into indices with values between 0 and 1. The maximum are the highest values that can be observed while minimum values can be considered subsistence values.

Step2. Add the subscripts to obtain the Human Development Index. The HDI is the geometric mean of the indices of the three dimensions:

$$\left(I_{life}^{1/3}\right)\cdot\left(I_{education}^{1/3}\right)\cdot\left(I_{income}^{1/3}\right)$$

2.2. Profitability Index

The economic income obtained per fishing spot throughout the fishing season is presented in the equation (FAO, 2002):

$$\pi_{khm}(t + DT) = \pi_{khm}(t) + \int_{t}^{t+DT} \left(IT_{khm}(\tau) - CT_{khm}(\tau)\right)d\tau$$

Where:

$IT_{khm}(t)$= total income received by fisherman *m* with base site *h* by capturing target species at fishing site *k* at time *t*.

$CT_{khm}(t)$= total costs incurred in fishing effort by fisherman *m* while fishing at site *k* at time *t*.

Expressions for $IT_{khm}(t)$, and $CT_{khm}(t)$ are presented in the equations:

$$IT_{khm}(t) = (q_m B_k(t) P_{tar}) f_{khm}(t)$$
$$CT_{khm}(t) = FC_m V_m f_{khm}(t)$$

Where:

P_{tar} = average price paid to fisherman per kg of target species.
q_m = coefficient of catchability of boat type *m*.
$B_k(t)$= biomass of target species at fishing site *k* at time *t*.
FC_m = fixed daily cost for vessel type *m*.
V_{hm} = number of boats type *m* from site *h*.

3. Results

Among the characteristics that make up the profile of a fisherman, which are presented in Table 1, reference is made to the sociodemographic characteristics of this population. In general terms, one can see that this is a middle-aged population. It is worth mentioning that, unlike other types of fisherman populations composed of very young people engaged in the activity, in the case of prawn fishing, the youngest fisherman identified is 27 years old, and a significant 12% is over the age of 60. According to survey results, all the fishermen are male. The education level of those interviewed is relatively low; 18% have some level of primary education but claim to have had to drop out before completing primary school, 43% reported having completed the first six years of basic education, while 6.2% attended secondary school and only 6% finished their high school education; the remaining 6% have no level of formal education. Regarding aspects related to productive activity, 93% have a wooden boat to navigate along the river and be able to check traps. Most of the fishermen work unaccompanied; only 19% reported working with someone else. The number of years of fishing experience ranges mostly between 2 and 6 years. The workday of fishermen is influenced by weather conditions and by the presence of target resources. In addition, the schedule of artisanal fishermen such as prawn fishermen is highly influenced by the specific task they perform.

In the case of prawns, the most time-consuming work is placing traps, which is usually done in one or two days. Afterwards, fishermen only check and possibly change the location of some traps. The current average number of hours worked per day is estimated at 4. Undoubtedly, an important variable that influences the number of hours worked per day is the number of traps placed per fisherman. Descriptive measures are presented on table 3.

One interesting datum is the relation between the number of traps placed per fisherman and the number of years dedicated to prawn fishing; the results show a direct relationship between these two variables. Even more interesting is when we add the number of years a fisherman has engaged in fishing in general; while the most experienced prawn fishermen have fished only prawns, those who for only a year or two have engaged in fishing for this crustacean are overall more experienced fishermen, who indicated that the number of traps placed is related more to the cost of the investment for traps rather than to any other variable. (See figure 1)

In table 4 are presented the economic indices obtained for each boat used for prawn fishing in Loma Bonita, Oaxaca. Productivity per hour and physical productivity per worker are two factors that stand out. The opportunity cost when represented by the average interest rate of 2013 is very low compared with the value of the production obtained.

3.1. Principal Component Analysis

The concept of quality of life is defined as the quality of an individual's living conditions or as the satisfaction experienced by a person with certain vital conditions, in other words the combination of objective and subjective components, i.e., the quality of a person's living conditions together with the satisfaction experienced. In the present study, some indicators have been selected which are considered to measure, at least socially, the socioeconomic level of these people. For a better understanding, the indicators were divided into 3 dimensions: In the first type is identified the type of housing a fisherman has based on the materials that have been used for its construction; in dimension 2 are included those implements which are considered necessary so that a dwelling can facilitate everyday activities, while in dimension 3 are shown the results of basic public services.

The quality of housing for the group of fishermen interviewed were especially lower in those variables whereby it was possible to identify more closely the potential income effect, namely telephone or car; the group of fishermen showed less frequent ownership of these items.

However, regarding building materials used for housing as well as access to public services, the group was homogenous.

To determine this index, three dimensions were defined: Dimension 1 refers to the structural conditions of the fishermen's housing; the maximum value for this index given the number of fishermen and the weighting of 0.33 for each feature of the three variables that comprise the dimension is 95.4; the obtained result was 67.6. For dimension 2, the weighting was 0.14, and the index that optimizes equipment conditions according to the selected variables would be the equivalent of 31.36; the obtained result in this study was 21.6. And finally for dimension 3, related to access to most relevant public services, the maximum index would be 31.5, while 30.8 was obtained. Given this evidence, it is considered that these fishermen fall not within the lower strata of poverty but rather within a middle socioeconomic level and with sufficient resources for small investment. It is worth noting that since prawn fishing is temporary, income per fisherman is not obtained exclusively from fishing, for which the data may contain some bias. (See tables 5, 6 and 7).

The Human Development Index (HDI) is an indicator created by the United Nations Development Programme (UNDP) for the purpose of determining a country's level of development. It was devised in order to not only know the income of people in a country but also assess whether the country provides its citizens an environment in which they can develop their projects and improve their living conditions. The HDI provides index values between 0 and 1, 0 being the lowest and 1 the highest rating. In this sense, the UNDP classifies countries into three groups:

- Countries with High Human Development (HDI higher than 0.80)
- Countries with Medium Human Development (HDI between 0.50 and 0.80)
- Countries with Low Human Development (HDI less than 0.50)

Based on these indicators, Oaxaca would be placed in the range of countries with medium human development. It should be noted, however, that for the indicator of Oaxaca the national average income was used since no specific data for Oaxaca was found for the year analyzed, so it could differ from the real indicator but is consistent with that calculated by the UN in 2010 (see table 8). Since these fishermen are in the lower range of the ranking with a value of 0.43, they are considered as having low human development, which implies poor living conditions according to international standards.

3.2. Profitability Indicators

The available adjusted net household income is the amount of money a family receiveseach year after taxes. It represents money that a family has for spending on goods and services. The available household income consists of income from economic activity (wages and salaries), benefits from those working in their own business, income from property (dividends, interest and rents), social cash benefits (retirement pensions, unemployment benefits, economic assistance from other family members, subsidies for low income, etc.) and social transfers in kind (goods and services such as health services, education and housing received for free or at reduced price).
The income of these fishermen is derived entirely from the economic activities in which the family is engaged; they do not have social benefits or transfers. From Table 9 it can be deduced that the highest percentage (56%) of fishermen have an income in the range of $1,500 to $ 2,500 MXN(Mexican pesos), which can be recognized as low if we consider that the minimum monthly wage for the area, according to the National Minimum Wage Commission, is $1841.40 MXN. Thus, it can be seen how income may constitute a constraint to the development of the artisanal fisheries sector in the sense that it impairs the ability of fishermen to meet their socio-familial needs and prevents the productive investment necessary to boost the sector.

3.2 Index of Economic Profitability

To calculate the cost of traps (see table 10), mesh traps were chosen over basket traps because they happened to be slightly more common and because once depreciation is calculated the cost per year is very similar since basket traps are much cheaper but deteriorate more quickly and can be used for less time. The letter *n* for this cost represents the number of traps; in this case the average was used, calculated after the exclusion of one fisherman whose number of traps is 5 times higher than the mode.

With regard to transport for moving the product to market, this is also quite varied, ranging from bicycle or horse to car. The price of taxi service was taken as a reference to determine this cost.
The table 11 shows the calculation of income per boat. It is worth noting that, in the case of prawn, incidental catch is not intended for sale but rather for personal consumption and therefore is not included in this calculation, nor are small and female fish taken into account as they are returned to the water.

As had been assumed, the profitability of prawn fishing is high especially when compared with fishing for more common species in the region; and since the goal was to get an idea of the profitability of the species, this calculation results in a handsome profit for fishermen. (Table 12).

4. Conclusions

From the findings obtained from this research, it is concluded that there is indeed some differentiation between the fisherman dedicated to prawn fishing and what is known of the traditional fisherman. The prawn fisherman is an opportunity fisherman whose main source of income is not fishing. He is not dedicated to this activity by way of family tradition since his experience in the field is relatively recent and the age range is significantly smaller, i.e., most are middle-aged adults. It should be noted that over the years more and more traditional fishermen have been taking up prawn fishing, so this profile could be expected to change if the trend continues.

The profile obtained also agrees with indicators of housing quality, which were not so disappointing given the rating assigned to each variable; however, when the indicator further notes the quality of living of the fishermen, and more importantly when it is compared with the standard proposed by international organizations, it is in fact disappointing. This observation is interesting because in the event that aqua cultural production of this species becomes possible, most of these fishermen will not be able to pursue it with their own resources, in which case government intervention would be necessary.

Finally, even though the performance indicator was high (1.6) since for every peso invested the profit was almost 100%, the loss appears to be very disappointing since only 20% of the costs invested was recovered; so one would expect that this would cause repercussions on the number of people engaged in this activity, subtracting significantly from the number of fishermen for the next season while leaving only those whose losses are less than their fixed costs. It is for this reason that it is highly recommended that this study be continued in order to corroborate that in fact the year 2013 was an atypical year and not a future trend in the behavior of prawn fishing.

5. *References List*

Arevalo R (1999) Construcción de un índice de calidad de vivienda. Investigaciones Económicas XXII: 267-280.

Astier M., Masera O., Y. Galván-Miyoshi. (2008). Evaluación de sustentabilidad. Un enfoque dinámico y multidimensional. SEAE / CIGA / ECOSUR / CIEco / UNAM / GIRA / Mundiprensa / Fundación Instituto de Agricultura Ecológica y Sustentable, España. Primera Edición. Valencia. España, (Chapter 2).

Fleiss, J. L.: Statistical Methods for Rates and Proportions.John Wiley & Sons, New York-London-Sydney-Toronto (1973). XIII, 233 S. (Chapter 4)

Food and Agriculture Organization of the United Nations (2002), La estiación de indicadores económicos en las pesquerías Mediterráneas. Roma, Italia. (Chapter 2)

Food and Agriculture Organization of the United Nations y La Comisión Permanente del Pacífico Sur. (2007). Estudio sobre impacto socioeconómico de las pesca artesanal en los estados miembros de la comisión permanente del pacífico sur. Guayaquil, Ecuador. FAO y CPPS. 33p

Meixueirio J., Pérez A. (2008). Metodología General para la Evaluación de Proyectos. Banco Nacional de Obras y Servicios Públicos. S.N.C. Centro de Estudios para Preparación y Evaluación Socioeconómica de Proyectos. México. DF., (Chapter 3)

INEGI,(2000), Regiones socioeconómicas de México. [Online] Available: http://sc.inegi.org.mx/niveles/datosnbi/reg_soc_mexico.pdf (November 13,2014)

CINASAMI,(2013),Salarios mínimos. [Online] Available: http://www.conasami.gob.mx/pdf/tabla_salarios_minimos/2013/01_01_2013.pdf (November 13, 2014)

Klugman, Jeni, Human Development Report (2011). Sustainability and Equity: A Better Future for All (November 2, 2014). UNDP-HDRO Human Development Reports, 2011. [Online] Available: SSRN: http://ssrn.com/abstract=2294671

Programa de las Naciones Unidas para el Desarrollo Humano, (2009), Informe sobre desarrollo humano. [Online] Available: http://hdr.undp.org/sites/default/files/hdr_2009_es_complete.pdf

Vázquez M.; Carmardiel A. y Ramírez G. (2000), Revista Venezolana de Análisis de Coyuntura, 2000, Vol. VI, No. 1 (ene-jul), 121-142.

World Bank, (2011), PPP conversion factor, GDP (LCU per international $). World Development Indicators & Global Development Finance 2011. [Online] Available: http://data.worldbank.org/country/mexico (November 10, 2014).

Table 1: Economic Indicators per Unit of Fishing

Indicator	Description	Algorithm	Symbology
Physical Productivity per Fisherman (PPF)	Expresses average weight contribution per fisherman	$PPF = TP/P$	TP= Total Product P = Fisherman T=Hours dedicated to fishing VP= Value of the Total Production E=Number of people employed IC=Invested Capital i=Interest rate
Physical Productivity per Hour (PPH)	Expresses average weight contributionper complete hour of fishing activity	$PPH = TP/T$	
Productivity per Hour (PH)	Expresses average proceed value contribution per hour spent fishing	$PH = VP/T$	
Physical Productivity per Worker	Expresses average weight contribution per worker	$PFT = PT/E$	
Productivity of Labor	Expresses average value contribution per worker	$PL = VP/E$	
Average Price	Indicates price per kilogram of production	$PM = VP/PT$	
Opportunity Cost	Expresses income that owner could obtain fromcapital invested in fishing	$CO = IC * i$	

Table 2: Calculation of Human Development Indices: Graphical Presentation

Human Development Index (HDI)	Dimensions	Long and healthy life	Education		Decent standard of living
	Indicators	Life expectancy	Average # of years of education	# of years of education expected	*Per capita* income
	Index of dimension	Index of life expectancy	Index of Education		Income/Consumption
	HUMAN DEVELOPMENT INDEX				

Table 3: Descriptive Measures

Variable	N	Mean	Median	Mode	Max.	Min.	σ
No. of boats	32	1.1	1	1	3	1	0.3
Experience (years)	32	5	4	2	17	2	3.6
No.of people (per boat)	32	1.1	1	1	2	1	0.3
Workday (in hours)	32	4.2	5	5	6	2	1.1
Age	32	41	39	44	71	21	9.5
Education	32	5.3	6	6	12	0	2.6
Income	32	3221	3000	4000	5500	1500	978

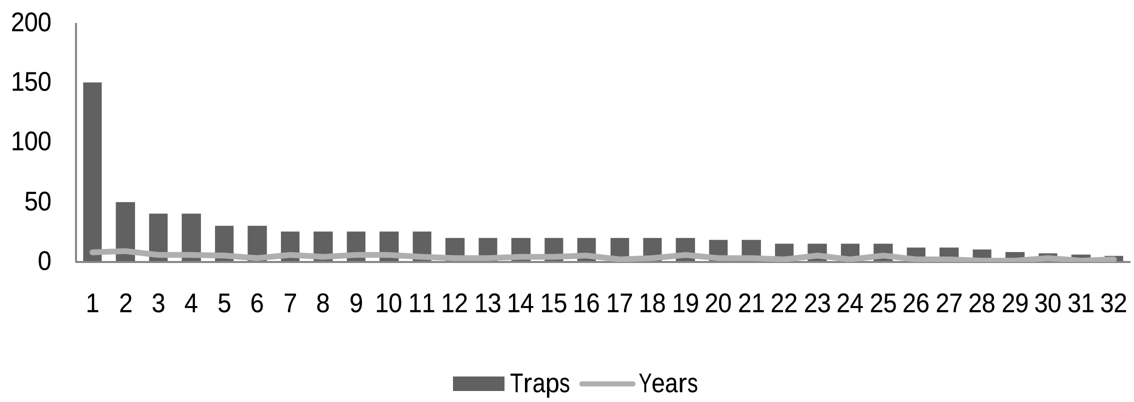

Figure 1: Relation between Number of Traps and Years Dedicated to the Activity

Table 4: Results of Economic Indicators per Unit of Fishing

Indicator	
Physical Productivity per Fisherman (PPF)	217 Kg.
Physical Productivity per Hour (PPH)	27.9 Kg.
Productivity per Hour (PH)	$3,084
Physical Productivity per Worker	182.7 Kg.
Productivity of Labor	$20,098
Average Price	$110
Opportunity Cost	$410

Table 5: Dimension 1

Structural conditions of fishermen's housing				
Variables included	Category			
	Type	Code	%	$a_{jk}x_{jk}$
	Tile	3	0	
Floor	Cement	2	100	21.12
	Dirt	1	0	
	Cement	3	12.5	3.96
Roof	Corrugated metal sheet, Tile	2	87.5	18.48
	Palm	1	0	
	Construction brick (tabique), Concrete block	3	100	31.68
Walls	Wood, Asbestos sheet	2	0	
	Cardboard sheet	1	0	
				I_{D1}=75.24

Table 6: Dimension 2

Household equipment			
Variables included	Category		
	Owned (Code 1)	Not owned (Code 0)	$a_{jk}x_{jk}$
Refrigerator	75%	25%	3.3
Gas stove	100%	0%	4.4
Washing machine	62%	38%	3.0
Vehicle	37%	63%	1.6
Cell phone	75%	25%	3.3
Telephone	43%	57%	1.9
Television	87%	13%	3.8
			I_{D2} = 21.3

Table 7: Dimension 3

Access to services			
Variables included	Category		
	With (Code 1)	Without (Code 0)	$a_{jk}x_{jk}$
Water supply	100%	0%	10.5
Electricity	100%	0%	10.5
Sewage	93%	7%	9.8
			I_{D3}=30.8

Table 8: Calculation of Human Development Index of the Fishermen

Indicator	Oaxaca	Maximum	Minimum	Indices
Life expectancy*	72.8	83.4	20	$Iv = \frac{72.8 - 20}{83.4 - 20} = 0.83$
Average # of years of education*	5.5	13.1	0	$Ipe = \frac{5.5 - 0}{13.1 - 0} = 0.42$
#of years expected to study	13.9	18	0	$Iei = \frac{13.9 - 0}{18 - 0} = 0.77$
Education	0.58	0.97	0	$Ie = \frac{\sqrt{0.42 * 0.77} - 0}{0.97 - 0} = \frac{0.56}{0.97} = 0.58$
Income per capita**	2853,12	120,500	1307	$Iy = \frac{\ln(2853) - \ln(1307)}{\ln(120500) - \ln(1307)} = \frac{0.78}{4.52} = 0.17$
$HDI_{(FISHERMEN)} = \sqrt[3]{0.83 * 0.58 * 0.17} = 0.43$				

*Data provided by INEGI 2010 **Data provided by CINASAMI 2013

Table 9: Family Income

Monthly incomein pesos (MXN)					
1500-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500
44%	12%	3%	3%	28%	10%
Mean	Mode	Max.	Min.	σ	
2853	4000	4500	1500	1084	

Table 10: Cost per Season per Boat in Prawn Fishing 2014

COSTOS				
Fixed costs	Unit	Price	Calculation	Season
◦ **Boat**	1	5000	$[Initial\ Cost * \%\ depreciation]$	650
◦ **Trap**	1	150	$[(Initial\ Cost * \%\ depreciation) * n]$	1000
◦ **Net**	1	15		15
◦ **Transportation**	Trip	25	$[Cost * trips\ taken]$	1550
◦ **Labor**	Day	150	$[Cost * days * n]$	11160
Variable costs				
◦ **Bait**	Mix	15	$[Cost * n]$	300
Total costs				
			$CT_{khm}(t) = FC_m V_m + CV_{khm}(t) f_{khm}(t)$	$14,675.00

Table 11: Income per Season per Boat in Prawn Fishing 2014

Coefficient (q_m)	**Biomass (Bk(t))**	**Price (P)**	**Calculation**	**Income**
678	0.32 kg.	$110	$IT_{khm}(t) = (q_m B_k(t) P_{tar})$	$23,865.00 MXN

Table 12. Economic Profitability of Prawn

Indicator
$\pi_{khm}(t) = \int_t^{t+DT} (IT_{khm}(\tau) - CT_{khm}(\tau))$ **= $ 9,190.00**