Agroforestalis News, v.4, n.1, p.10-21, 2019
[http://www.seer.ufs.br/index.php/AGRO]
ISSN 2525-6920 Seção Artigos

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EXPLORATORY DATA ANALYSIS FOR ANOMALY DETECTION IN ILLEGAL FISHING RECORDS IN THE AMAZON BASIN

ANÁLISE EXPLORATÓRIA DE DADOS PARA A DETECÇÃO DE ANOMALIAS NOS REGISTROS DA PESCA ILEGAL NA BACIA AMAZÔNICA

ABSTRACT

The present study analyzed the records of illegal fishing in the Amazon Basin, based on the seizure records drawn up by the Brazilian Institute for the Environment and Natural Renewable Resources (IBAMA) in Manaus City, Amazon State, from the year of 1992 to 2017. A total of 1,875 records (539.36 tons of apprehended fish), which occurred mainly in the rivers Solimões (1,294.09 tons), Negro (869.36 tons), Purus (230.31 tons), Japura (179.71 tons), Amazonas (95 tons), 02 ton) and Juruá (69.91 tons), with a total of fish seized around 2,765.70 tons. A total of 34 fish species were identified, the main ones were pirarucu (*Arapaima gigas*) with 66.12%, followed by tambaqui (*Colossoma macropomum*) with 21.70% and Surubim (*Pseudoplatystoma fasciatum*) with 2.82%, the other species grouped together with 9,36% of the seizures. Were applied the technique of exploratory data analysis associated to the control chart for the detection of outliers in the apprehended fish record time series of the data, in which anomalies were verified in the quantitative of fish seized from the years 1999, 2000, 2001 and 2003, which oscillated at 409.81 tons, 493.37 tons, 530.59 tons and 310.79 tons of apprehended fish, respectively. There was a marked decrease in seizures after the validity of the Defense Law, emphasizing that its happened due to its compliance, which combined with the intensification of inspections, can make sustainability of inventories feasible. However, it is immature to say that this decrease behaviour occurred only due to the creation of the aforementioned Law, but others causes should also be considered in the current scenario, as external factors that may have influenced the result, such as the reduction of existing fish stocks, difficult access to fishing environments and the lack of effective monitoring and surveillance of fisheries in these areas, as well as the decentralization of inspecione, previously performed exclusively by IBAMA, to the others governamental agencies.

KEYWORDS

Amazon, confiscation, supervision, fishing resources.

RESUMO

O presente estudo analisou os registros da pesca ilegal na bacia Amazônica, a partir dos autos de apreensões de pescado lavrados pelo Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) em Manaus, Amazonas, do período de 1992 a 2017. Foram averiguados 1.875 registros de infrações (539,36 toneladas de peixes apreendidos), estas ocorreram seguidas de apreensões de pescado, principalmente nos Rios, Solimões (1.294,09 tons), Negro (869,36 tons), Purus (230,31 tons), Japurá (179,71 tons), Amazonas (95,02 tons) e Juruá (69,91 tons), com um total de peixes apreendidos em torno de 2.765,70 toneladas. Foram identificadas 34 espécies de peixes, sendo as principais o pirarucu (Arapaima gigas) com 66,12%, seguido do tambaqui (Colossoma macropomum) com 21,70% e do Surubim (Pseudoplatystoma fasciatum) com 2,82%, as demais espécies agrupadas somaram 9,36% das apreensões. Foi utilizada a técnica de análise exploratória de dados associado ao gráfico de controle para a detecção de outliers *na série temporal dos dados das autuações, em que foi comprovado anomalias no quantitativo de pescados apreendidos, nos anos de 1999, 2000, 2001 e 2003, que oscilaram em 409,81 ton, 493,37 ton, 530,59 ton e 310,79 toneladas de peixes, respectivamente. Houve uma acentuada diminuição nas apreensões após a vigência da Lei do Defeso, abalizando-se que seu devido cumprimento, conciliado à intensificação das fiscalizações pode viabilizar a sustentabilidade dos estoques. No entanto, é imaturo afirmar que essa diminuição se deva somente a criação da referida Lei, devendo ser considerado também no atual cenário, fatores externos que possam ter influenciado no resultado, como a diminuição dos estoques de peixes existentes, difícil acesso aos ambientes de pesca e a falta de efetivo para a fiscalização e monitoramento das pescarias nessas áreas, como também a descentralização das fiscalizações, anteriormente executada exclusivamente pelo IBAMA, à outros órgãos governamentais.*

PALAVRAS-CHAVE

Amazônia, apreensão, fiscalização, recursos pesqueiros.

Recebido em 18/03/2019; Aprovado em 21/05/2019.

1. INTRODUCTION

The fishing activity at the Amazon basin stands out when compared with other Brazilian regions because of the diversity of exploited fish species and due to local population's dependence of this extractive activity (BAYLEY; PETRERE, 1989). Fish is the main source for animal protein for riverside populations and urban centers in the north of the country, who can consume up to 805 g/per capita per day (RUFFINO; ISAAC, 1994; CERDEIRA et al. 1997; BATISTA et al. 1998; RUFFINO et al. 2006). Fish consumption has increased significantly during the past two decades (WOO; BRUNO, 2006), consequently, pressure over fish stocks has increased as well (ISAAC; BARTHEM, 1995). However, the exploration of this resource has been conducted in a disorderly manner and, in a few cases, it's illegal, which directly contributes to reduction in natural stocks, in almost all of Brazilian regions, especially in the Amazon region, where it's harder to control, because of the vast territorial growth and limited access to more remote communities (BORGES et al. 2007; DIAS NETO, 2010).

In order to understand the dynamics of fisheries in Amazon wetlands, fishing researchers have exhaustively been trying, through most varied analysis techniques, to subsidize statistical information (RUFFINO et al. 2006; ISAAC et al. 2012) which can help in decision-making processes and promote the rational use of fishing resources (FAO, 2002). Thus, some management strategies have been developed, such as restrictions regarding the minimum catch size and prohibition on fishing certain species, in specific periods, which are called "closed periods" (BRAZIL, 2015). The latter is shown in Law number 10.779 of 2003, which aims to grant the benefit of a minimum monthly salary, during the closed period (four months) to the professional fisher, providing this individual with labor rights (BRASIL, 2003). However, the aforementioned law is enforced only within the limits of social and environmental policies; first, by providing the benefit to the fisher, and second, by ensuring the existing fishing stocks a period for its maintenance and recovery due to recruiting new types of fish which will be added to the population (CAMPOS; CHAVES, 2014).

Nowadays, the closed period is the main measure for fishing management in effect in the Amazon basin and, once it's associated with other restrictive measures, it aims to reduce pressure over these fish stocks, through monitoring and inspections which are intended for preventing the catches of target fishing species in their reproductive period (CORRÊA et al. 2014). From another perspective, the closed period suspends only the catch of a species group (those commercial species), which does not inhibit fishing activity in its entirety, and this makes this measure ineffective, once fisheries in Amazon are multi-specific (MERONA; BITTENCOURT, 1988; SANTOS; SANTOS, 2005; FREITAS; RIVAS, 2006). Simultaneously, it has been encouraging the activity in a negative way, by increasing the number of new members (fishers), who register themselves in the colonies and get started on fishing activity, increasing the fishing effort on the fish stocks, without concern about conservation, just ensuring themselves the receipt of the benefit provided to this labor class (CORRÊA et al. 2014).

On the other hand, the high complexity involved in fishing in the Amazon, makes it difficult for a thorough comprehension about some presuppositions of traditional models for evaluation on fishing stocks (FREITAS; RIVAS, 2006). So far, the use of analytical models is mostly based on data from landing fish

Recebido em 18/03/2019; Aprovado em 21/05/2019.

statistics, where the information on illegal catches is taken into consideration, which are performed by inspection organs, increasing uncertainty in the models estimates.

Therefore, a process to anomaly detection in the time series of confiscated fish data is a tool that can available to identify tendencies and to detect outliers, which correspond to extreme situations (HOAGLIN et al. 1992). Actually, the use of Exploratory Data Analysis (EDA) have being performed to identify these anomalies (TRIOLA, 2008; BUSSA; MORETTIN, 2013; LIMA et al. 2013), which are exhibited by control charts, that stands out the statistical domain status, also applied to monitor the fish production system (MONTGOMERY, 2004). In this regard, the use of EDA can be a tool capable to identify irregularity patterns or outliers in fishing production systems for the Amazon region.

However, the lack of researches on diagnosis of illegal fisheries is still a restriction for the whole understanding about the condition of current fish species exploitation. With a view to identifying their tendency on a long term basis, the scope of this research was to evaluate, through Exploratory Data Analysis, together with process control charts, the abnormality patterns or anomalies in spreading illegal catches of fish, recorded during the past 26 years, on the main rivers in Amazon basin, registered by Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), located in Manaus city, Amazonas state.

2. MATERIAL AND METHODS

2.1 Study area

The Amazon basin is the biggest hydrographic network worldwide, occupying a total area of 6,110,000 km², from its beginning in Peruvian Andes to its estuary in Atlantic Ocean (ANA, 2018). This enormous river basin covers several countries in South America, and 63% of its extension is in Brazilian territory (ANA, 2018). The area of study embraced the main rivers of the Brazilian Amazon basin, within the territorial borders of the Amazonas state (Figure 1).

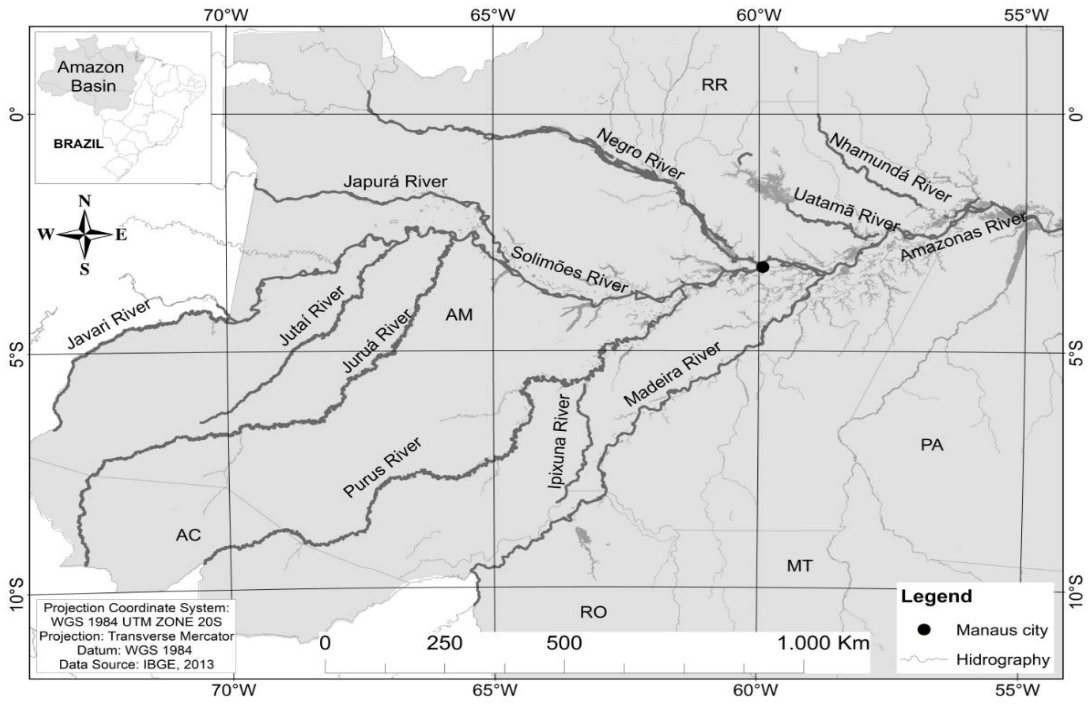

Figure 1. Main Amazon River tributaries where had occurrences of fisheries infractions and successive seizures of fish, between 1992 and 2017.

2.2 Data collection

The data related to confiscated fish between 1992 and 2017 was collected from the IBAMA governmental agency. Information on fishing statistics was collected on a census basis. These statistics data contained information associated with the infraction locations (rivers), absolute frequency of infraction records, fisheries production in tons, scientific and common names of species and fishing frequency by river sector.

2.3 Statistical analyses

At first, data file from the confiscation records was tabulated in electronic spreadsheets and later used for the production of maps, tables, and charts, aiming to obtain a better comprehension of its distribution throughout the Amazon basin. Also, the data was submitted to descriptive statistics for absolute and relative frequency identification and, therefore, in the use of average calculations and standard deviation.

As for data regarding time series of fish confiscations, a control chart (CC) was developed. According to (VIEIRA, 2014), it is used for identifying variability of a certain dataset, by monitoring if the fisheries data process is under control, so that the special causes of variation can be identified. The CC is based on the idea where variability remains in a stable range, and future observations can be foreseen through previous data existing within the estimated probability (PYLRO, 2008). The control chart representation is performed by three lines: central line (CL, which represents the average of values found in investigated characteristic), the lines from superior control limit (SCL) and, the inferior control limit (ICL), which are located symmetrically compared to CL (PYLRO, 2008).

In order to detect SCL and ICL, inequations 1 and 2 were used for the identification of abnormalities outliers in confiscation data series. Inequations followed guidelines by Barnet and Lewis (1994) which originate from Data Exploratory Analysis (DEA) for a univariate data set (MONTGOMERY; RUNGER, 2003; COSTA et al. 2004; MONTGOMERY, 2004).

$$O.I. < Q1 - 1.5 * (Q3 - Q1) \quad \text{(Inequation 1)}$$

$$O.S. > Q3 + 1.5 * (Q3 - Q1) \quad \text{(Inequation 2)}$$

Where,

O.I. = inferior outlier; *O.S.* = superior outlier; *Q1* = first quartile*; Q2* = second quartile = medium*; Q3* = third quartile, *(Q3-Q1)* = interquartile range.

A quartile makes up ¼ of the data shown, where the first quartile (inferior quartile, Q1) corresponds to 25% of total dataset. The second quartile (Q2) corresponds to average value where 50% of the sample is ordered. The third quartile or superior quartile (Q3) is the value which delimits 25% of higher values, equivalent to 75% of sample value (FONSECA; MARTINS, 2006).

3. RESULTS AND DISCUSSIONS

3.1 Analysis on fishing infractions

During the study period, 1,875 infraction records were registered, 88.48% of which were distributed on the rivers Solimões (39.15%), Negro (27.73%), Amazonas (9.17%), Purus (7.47%), and Japurá (4.96%).

Recebido em 18/03/2019; Aprovado em 21/05/2019.

The other rivers, when grouped, reached a rate ranging around 11.52% of the total of seized fish. As for the number of total catches by fishing regions (rivers), distribution of confiscations was proven by 2,765.70 tons of fish, and 96.48% were concentrated on the rivers Solimões (46.79%), Negro (31.43%), Purus (8.33%), Japurá (6.50%) and Amazonas (3.44%) (Figure 2).

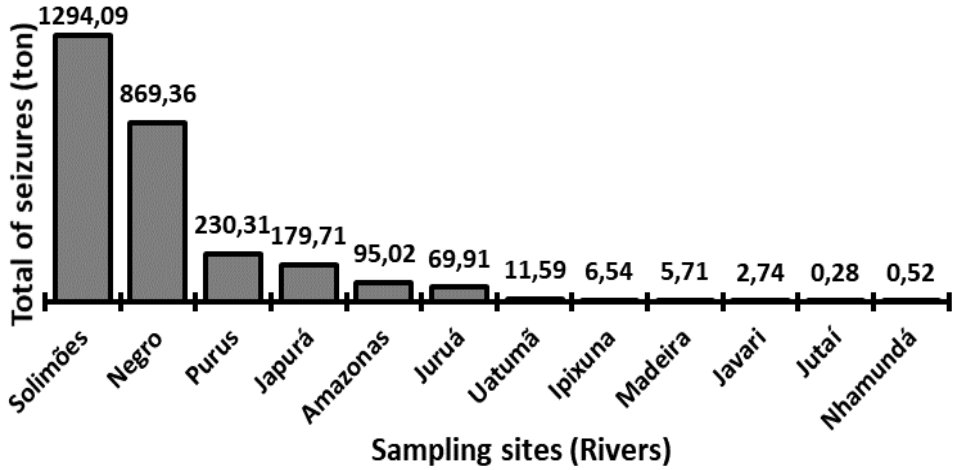

Figure 2. Total seizures of fish in tons and the respective rivers where were recorded occurrences of illegal fisheries.

3.2 Chronological series of seizures control chart

Considering the total of fish seized during sample period, the annual average obtained was 106.38 ± 152.56 tons (Figure 3). Dataset time variation concomitantly with inferior and superior limits of the values associated with the seizures showed for the years of 1999, 2000, 2001, and 2003 the highest records of seizures in tons, which oscillated in 409,81 ton, 493,37 ton, 530,59 ton, and 310,79 ton, respectively. Such data were higher than the superior limit (252, 23 ton), and they were classified as the time series outliers (Figure 3).

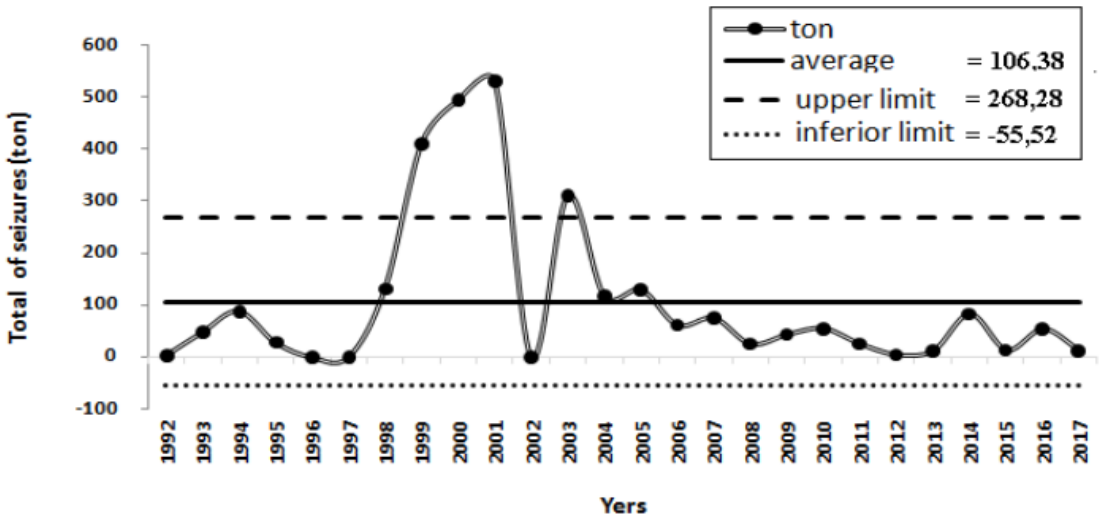

Figure 3. Analysis of the temporal distribution of fish seizures occurring in the Amazon basin, from 1992 to 2017. Indicating the values of mean, lower and upper limits of the data series.

3.3 Species seized

Thirty-four seized fish species were identified, and the following species were the most frequent ones, pirarucu (*Arapaima gigas*) with 66.12%, followed by tambaqui (*Colossoma macropomum*) with 21.70% and by surubim (*Pseudoplatystoma fasciatum)* with 2.82%, the other species reached 9.36% of the seizures (Table 1).

The occurrence of illegal fishing in the Amazon basin, which is reported in last decades, has been threatening stability and survival of fish stocks (DIEGUES, 2001; DIAS et al. 2013), and this is corroborated by the high number of records in illegal fishing (CORRÊA et al. 2014; CAVOLE et al. 2015). This is a consequence mostly brought about the existence of a rich aquatic biodiversity, which is an attractive factor for formal and informal fishers, which has become more serious doe to the vast territorial extension of the Amazon, which makes it difficult for the enforcement on users of the fishing resource (GASALLA; YKUTA, 2015).

Table 1. Absolute and relative frequencies of seizures (tons) per fish species in the Amazon basin occurred between the years of 1992 and 2017.

Scientific name	Common name	Seizure fish (tons)	Fr
Ageneiosus brevis (Steindachner, 1881)	Mandubé	3.17	0.11%
Anostomoides laticeps (Eigenmann, 1912)	Aracu-cabeça-gorda	0.03	0.00%
Arapaima gigas (Cuvier, 1829)	Pirarucu	1,828.67	66.12%
Astronotus ocellatus (Agassiz, 1831)	Acará-açu	0.17	0.01%
Brachyplatystoma filamentosum (Lichtenstein, 1819)	Piraíba	4.17	0.15%
Brachyplatystoma juruense (Boulenger, 1898)	Dourada-zebra	1.58	0.06%
Brachyplatystomapla tynemum (Boulenger, 1898)	Babão	0.51	0.02%
Brycon amazonicus (Agassiz, 1829)	Matrinxã	6.64	0.24%
Brycon melanopterus (Cope, 1871)	Jatuarana	0.04	0.00%
Calophysus macropterus (Lichtenstein, 1819)	Piracatinga	0.72	0.03%
Cichla temensis (Humboldt, 1821)	Tucunaré	6.71	0.24%
Plagioscion squamosissimus (Heckel, 1840)	Pescada	1.69	0.06%
Colossoma macropomum (Cuvier, 1816)	Tambaqui	600.12	21.70%
Hydrocynus goliath (Boulenger, 1898)	Tigre-zúnguro	0.07	0.00%
Hypophthalmus marginatus (Cuvier & Val., 1840)	Mapará	22.70	0.82%
Leporinus agassizi (Steindachner, 1876)	Aracu	0.12	0.00%
Piaractus mesopotamicus (Holmberg, 1887)	Pacu-branco	3.22	0.12%
Mylossoma duriventre (Cuvier, 1818)	Pacu-manteiga	10.05	0.36%
Osteoglossum bicirrhosum (Cuvier, 1829)	Aruanã-branca	34,39	1.24%
Osteoglossum ferreirai (Kanazawa, 1966)	Aruanã-preta	0.04	0.00%
Oxydoras niger (Valenciennes, 1840)	Cuiú-cuiú	0.06	0.00%
Phractocephalus hemioliopterus (Bloch & Schn., 1801)	Pirarara	1.89	0.07%
Piaractus brachypomus (Cuvier, 1818)	Pirapitinga	2.50	0.09%
Pimelodina flavipinnis (Steindachner, 1876)	Mandir-moela	0.56	0.02%
Prochilodus nigricans (Agassiz, 1829)	Curimatã	21.07	0.76%
Pseudoplatystoma fasciatum (Linnaeus, 1766)	Surubim	77.90	2.82%
Pseudopimelodus mangurus (Valenciennes, 1840)	Jaú-sapo	0.701	0.03%
Pseudoplatystoma tigrinum (Cuvier & Val., 1840)	Caparari	0.32	0.01%
Rhaphiodon vulpinus (Spix & Agassiz, 1829)	Peixe cachorro	0.01	0.00%
Semaprochilodus insignis (Jardine, 1841)	Jaraqui-escama-grossa	45.42	1.64%
Semaprochilodus taeniurus (Valenciennes, 1817)	Jaraqui-escama-fina	42.39	1.53%
Serrasalmus rhombeus (Linnaeus, 1766)	Piranha-branca	0.01	0.00%
Triportheus angulatus (Spix & Agassiz, 1829)	Sardinha	3.11	0.11%
Paulicea lutkeni (Machado et. al., 1998)	Jaú	0.52	0.02%
Total		2.721,19	

Fr = relative frequency.

Recebido em 18/03/2019; Aprovado em 21/05/2019.

Fishing activity in the Amazon region is performed according to seasonality of river fluctuations (SOUZA et al. 2016; SOUSA et al. 2017), comprising the period between December and April (rising water), May and June (flood), from July to September (receding water), October and November (drought) (BITTENCOURT; AMADIO, 2007). The closed fishing season is coincident with the rising water season, which invades the flood plain areas that are places hard to be reached by motorized boats employed by the environment officers. Thus, this environmental factor enables the activity of illegal fishers who are experienced in fishing in flooded areas, where they use small paddling boats making access easier for fishing segments (SOUSA et al. 2017), which consequently implies in decreasing the stocks of natural fisheries (CAVOLE et al. 2015).

The Federal Law 9,605, of February 12th 1998 was created to protect the fish stocks during the reproductive season of several fish species of high commercial importance. This law addresses environmental crimes and establishes penalties for violators, both in criminal and administrative spheres. Also, it determines general and specific rules regarding the closed periods during the natural reproduction period of target fish species, in fishing activities, making it essential for maintenance of fish population, especially the overexploited fish species (BRAZIL, 1998).

However, reliability on closed season and compensatory payment to fishers, which is called closed season insurance payment, regulated by Federal Law 10,779, of November, 25th, 2003, have proven the inefficiency of this fishery policy, because it falls short of reaching the objectives proposed by the law, which makes it necessary to revise it and reformulate it, due to the inefficiency of its forms presented for executing its actions (CORRÊA et al. 2014), especially those related to respecting the closed season and inspection frequency; the latter one is due to lack of financial and human resources (DIAS et al. 2013) which makes it easy for the increase of illegal fishing in the region (DIAS et al. 2013; CORRÊA et al. 2014).

In fact, these measures aim, *a priori*, to inhibit the illegal practice of fishing, since it is during the period of closure that the fish are at the moment of greatest vulnerability, because when they migrate upstream, and do so in schools, they facilitate their catch, not reaching their ultimate goal, which is the reproduction and maintenance of fish stocks. Therefore, when the fisheries time is closed, professional fishing is prohibited to catch some fish species and it limits its quantity of fish to an amateur fishermen amount, in the same way for those who use the fish as subsistence, it restricts the means of capture whose function is the development sustainable and economically feasible (BRAZIL, 2015).

When were observed the number of seizures of fish caught in the last three decades, there were significant peaks in the records of this activity in areas of different river basins. The total amount of seized fish in tons during the study period was 2,765.70, of which 96.48% of the fish were concentrated in only five rivers, among the thirteen rivers analyzed: Solimões, Negro, Purus, Japura and Amazon. This phenomenon may be a reflection of the concentration of the inspection effort on illegal fishing due to the direct presence of IBAMA, that is located its office in Manaus city, a fact that facilitates the officer's access to the fisheries areas.

However, this information is clearer through time series data analysis, which obtained scenario profiles corresponding to periods from 1992 to 2003 (before Closed Season Law) and from 2004 to 2017 (effectiveness of Closed Season Law). In the decade prior to the implementation of the Closed Season Law,

Recebido em 18/03/2019; Aprovado em 21/05/2019.

there were a high number of fish confiscations from clandestine fisheries, which represented 74% of the total occurrences. In this period, there were records of Exploratory Data Analysis (EDA), anomalies (outliers) in confiscation sceneries corresponding to the years of 1999, 2000, 2001 and 2003, when a total of 2,046.02 tons of fish were confiscated. On the other hand, in the next decade, between 2004 and 2017, EDA showed a normal rate in data frequency around the average of 106,36 tons, showing a decrease of 26% compared to the total of confiscations in those records, which range from 117.69 tons in 2004 and 12.93 tons in the year of 2017.

The considerable number of fish seizures, related to the commercial fisheries production landed during the study period, indicates that the practice of clandestine fisheries carried out by amateur fishermen, who, as a rule, acts in the margin of the legislation in force. Thus this group of fishermen still evidencing the seizures, showed in the decade prior to the implementation of the Closed Season Law, where outliers of fisheries dataset were identified for this period exclusively. All infractions in fisheries indicates an clandestine nature of this illegal activity, whose profile is opportunistic, considering that it has been practiced during the closed seasons and/or in the protected areas, or with the fisheries effort on the juvenile fish, preferentially targeting species of higher commercial value, such as pirarucu (*Arapaima gigas*), tambaqui (*Colossoma macropomum*) and Surubim (*Pseudoplatystoma fasciatum*), which represented 90.64% of the total seizures in the Amazon basin.

The data frequency of fish confiscations, which is shown on time series chart, presented a fluctuation rate below average and close to inferior limit, identifying a decreasing confiscation pattern after 2003 with only two peaks in 2014 and 2016. However, these last records were considered to be within normality patterns, which indicate a stability tendency in the number of confiscations of illegal fisheries, and this factor allows for the continuing inspection process through monitoring the data behavior (MONTGOMERY, 2004).

This significant decrease in fish seizures after the implementation of Law number 10,779 of 2003, can be attributed to two main factors, first because of the national aquaculture policy, which has applied in an incisive and restrictive police to minimize the clandestine trade of fish, that becomes efficient for the containment of illegal fishing activity; and second, it can be attributed to the fact that some species such as tambaqui (*C. macropomum)* and jaraqui (*Semaprochilodus insignis*) landed in Manaus (PETRERE JR., 1983) and in the Lower Amazon areas, had a collapse indicative in its stocks (ISAAC; RUFFINO, 2000).

The fisheries negative impacts on the tagged fish stock occurred mainly on the tambaqui that happened probably due to a growing in fishing effort on this group of fish over the last three decades (BATISTA; PETRERE, 2003), as well with the others fish species such as: jaraqui (*Semaprochilodus* spp.) due to the capture of younger individuals and the increased demand for this specie (DIAS-NETO, 2015). Also Curimatã (*Prochilodus nigricans*) is suffering impacts on the growth and mortality rate in the Lower Amazon (CATARINO et al. 2014); caparari (*Pseudoplatystoma tigrinum*) and surubim (*P. fasciatum*) in the Middle Amazon due to the high demand of the slaughterhouses (ISAAC; CERDEIRA, 2004); for pirarucu (*Arapaima gigas*) that is already in overfishing of the stocks, as mentioned in the studies of Arantes et al. (2010) and Cavole et al. (2015), although it has already been included in the red list of species threatened with extinction (International Union for Conservation of Nature - IUCN) (CAVOLE et al. 2015).

It is also important to note that such species as pirarucu and tambaqui, in the present study were the

most expressive ones (87.82%) recorded in the seized fisheries, since the both fish were protected by specific legislation, the former being regulated by joint normative instruction (NI) as NI nº. 34, dated from June 2004, and NI nº. 01, of June 1, 2005, in which is prohibited fishing, transportation, storage and commercialization of pirarucu (*A. gigas*) in the State of Amazonas during the whole year; the second fish is regulated by NI nº. 35, dated of September 29th, 2005, which prohibited, from October 1st to March 31st, fishing, transportation, storage, processing and marketing of tambaqui (*C. macropomum*) in the watershed of the Amazon River. Finally, a third situation that can be attributed, which may explain the small apprehensions during the period of the closure of fisheries, such as the delegation and/or decentralization of inspections, formerly done exclusively by the IBAMA, became to the state agencies such as the Military Forces (Environmental Battalion – BPMA), and the Environmental Protection Institute of Amazonas - IPAM, and in these cases the fisheries inspections were drafted by these Federal Agencies.

In this context, disorderly exploration added to an increasing demand for fish defines a conflicting situation between economic development and environmental sustainability, which originate from population growth. As a result, there's the necessity of using the remaining fishing resources in a reasonable way (MURRIETA, 2001). In short, it is possible to notice that illegal fishing practice in Amazon basin has decreased after the implementation of Closed Season Law. If the rules established by this law are followed, if inspections are intensified by involving those people working with environmental awareness, especially regarding icthyofauna conservation and its biome, it is possible to promote preservation, maintenance, and conservation of fishing stocks in flooded areas in Brazilian Amazon.

4. CONCLUSIONS

The results showed that it's possible to evaluate, by using the math sample of exploratory data analysis (EDA), the distribution pattern of time series of infraction records in clandestine fishing in the Amazon basin, which occurred in the interstice from 1992 to 2017, where anomalies were detected in the frequency of records of this activity in the decade previous to incorporating the law for closed periods, followed by a decrease (normal pattern) in these records after the implementation of Closed Season Law.

Thus, it is understood that due fulfillment of the law for closed periods, combined with inspection intensification, can allow sustainability of remaining fishing stocks in this region. However, it is immature to state this reduction only exists due to the creation of Closed Season Law. Another factor to be taken into consideration in this current scenario is the external factors which might have influenced the result, such as the reduction of existing fishing stocks, hard access to fishing environments, and lack of personnel for inspecting and monitoring the fishing in those regions, as well as the decentralization of inspections, previously performed exclusively by IBAMA, for the State agencies.

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Recebido em 18/03/2019; Aprovado em 21/05/2019.