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Size Structure and CPUE of Hagfish (Eptatretus stoutii) Western Coast, Baja California, México

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Abstract: In order to evaluate the relative abundance of the myxinid (Eptatretus stoutii), the present work compares the size structure and the catches during the years 2010, 2011 and 2021 obtained in the development fishery for E. stoutii. The historical databases of the 2010 and 2011 seasons were analyzed; they were processed until obtaining the size structure and catch per unit effort in terms of catch per trap, to later compare it with the catches of 2021. The sizes of 1619 mixinids captured in the period of 2010, 2011 and 2021 were determined. The majority of the fish (66%) measured between 35 and 52 cm, while 6% was greater than 52 cm and 28% less than 35 cm. It was determined that the best catches were obtained in 2011 with 32,965 kg, using 31,680 traps. In 2021, a catch of 9,150 kg has been obtained with an effort of 19,604 traps, resulting in a higher yield than in previous years with 2,143 kg/trap compared to 0.702 and 1,041 kg/trap obtained in 2010 and 2011 respectively. This suggests a possible increase in the number of organisms vulnerable to fishing.

Key words: Hagfish, Eptatretus stoutii, trapping, fishing yield

1. Introduction

The Pacific Mixinid (Eptatretus stoutii) and the Black Mixinid (E. deani) are located in the northeastern Pacific. These two species of the Family Myxinidae are primitive fish that have a cartilaginous skeleton and lack eyes, jaws, scales, and pairs of fins [1]. The Pacific hagfish is the most abundant species and supports a fishery in the United States and Canada. It is distributed along the eastern Pacific coast, from southeastern Alaska to Punta San Pablo, Baja California (BC), Mexico. Preferable habitats are loamy and clayey bottoms with depths ranging from 16 to 966 m, a near-bottom salinity ranging from 31 to 32 elevations, and water temperatures < 10°C [2]. This species is an opportunistic scavenger of deep-scattering layer dwellers (euphasiids, cephalopods, sergestives, fish, and polychaete worms) [2-5]. Little is known about biology, ecology and behavior of the Pacific hagfish, beyond recognition of its low fecundity ranges from 11 to 48 developing eggs [6]. Females reach sexual maturity at about 32.5 cm in total length (TL and are between 7 and 12 years old [7]. The maximum size reported is 73 cm TL [8].

Of all the hagfish species in the world, 75% are listed as Data Deficient (DD) on the International Union for Conservation of Nature (IUCN) Red List. The Pacific witchfish is included in the DD category, as nothing is known about demographic productivity or resilience to fishing, including the population of hagfish in Mexican waters.

The hagfish fishery expanded from the Asian Pacific coast of the coast to other coastal states around the world [9]. In Mexico, La pesca del mixino is owned by a Korean company based in Ensenada, Baja, California (BC), operates with a special experimental fishing permit. The specimens are landed alive and, after acclimatization, shipped to Korea. Where there is significant demand. In Mexico there is no market for witch fish. Recently, the Mexican government has

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supported surveys to identify the abundance, distribution, and biology of hagfish from the northwestern coast of Mexico [10]. It is the hope that this information can serve as the basis for future stock assessments and fisheries management.

Currently, the main fishing resources in Mexico that support traditional, coastal, demersal or pelagic fisheries, are fully exploited [11]. Likewise, artisanal fisheries are carried out on all the coasts of both coasts of our country; however, the production is very varied in species but in many cases relatively low in quantity.

From this point of view and in the search for alternative resources to mitigate the uncertainty that affects fishing activity, programs have been carried out for exploratory and experimental fishing, in order to direct the capture towards deep-sea species such as the “painted witch” of the Pacific (Eptatretus stoutii) [10]. The E. stoutii fishery is in demand in the international market, particularly in the Asian market, since its demand can reach an attractive commercial value, so the development of its catch places it as a highly demanding activity in the short term.

In Mexico, the Pacific Painted Witch fishery is developed on the western coast of Baja California. Since 2006, it has been under the status of “Development Fishing”; this is that there is no tradition of fishing or processing. Due to administrative problems, this extractive work stopped its activities in 2012. After 9 years of inactivity, interest in its capture has returned.

In the present work, the current fishing yields are compared with those obtained in 2010 and 2011 during the semester that covers from the months of March to July, corresponding to the spring-summer cycle.

2. Methodology

2.1 Study Area

The Eptatretus stoutii species, known as “hagfish”, lives in the continental slope area, its geographical distribution is linked to the cold regions of the California current [6, 12]. The capture of the hagfish of the Pacific in Mexico is carried out in different areas of the western coast of the Baja California peninsula, these are Punta San Isidro, Punta Colonet, Bahía San Ramón, Bahía San Quintín, Bahía del Rosario and Punta San Carlos, the geographic coordinates of each area are shown in Fig. 1.

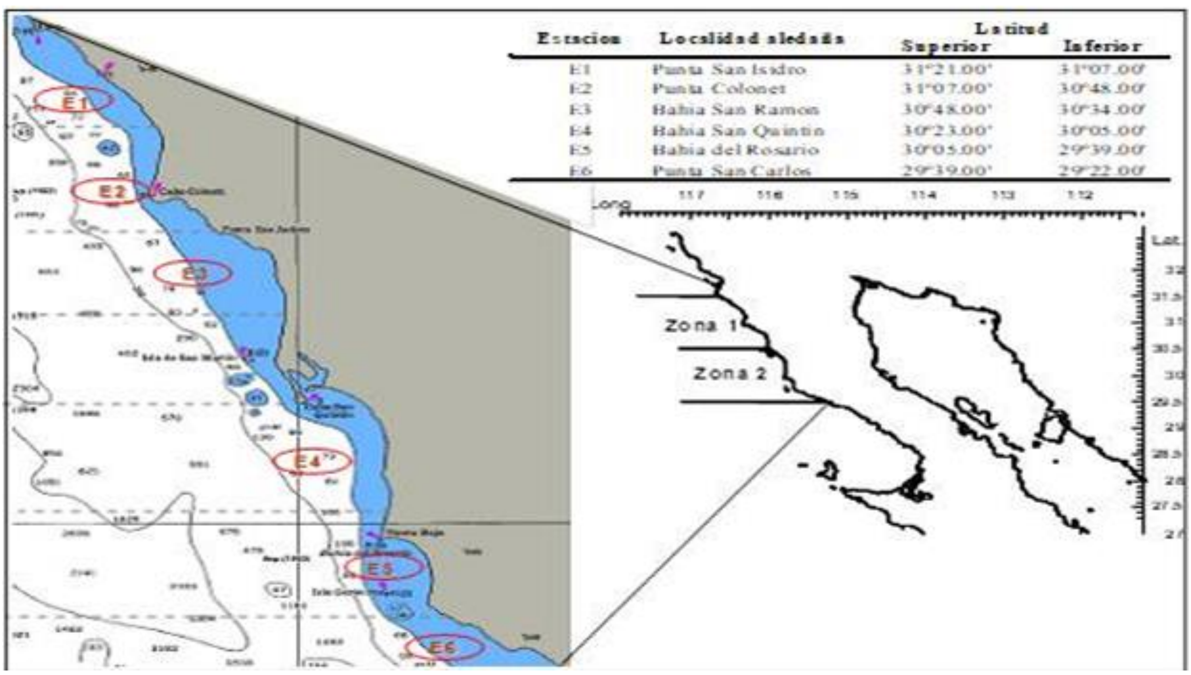

Fig. 1 Fishing locations where the Pacific hagfish experimental fishery was carried out during the spring period 2010-2011 and 2021.

2.2 Fishing Gear and Methods

To carry out this research, the Alaskeño vessel was used. Fishing for the hagfish (E. stoutti) can be done throughout the year. Two lines of 180 traps of the 200 l barrel type and another line of 150 traps with 30 l barrel traps (330 traps in total) were handled on the vessel. The 200 l drum type traps (Fig. 2) and 30 l barrel traps with circular lateral openings with two centimeters in diameter, through which a water exchange is promoted, so that the smell of the bait placed inside is dispersed in the environment more quickly (Fig. 2).

At both ends of the trap there is a plastic funnel that allows the animal to enter, but prevents its escape (Fig. 2). These traps are attached to the main line, through the reinal and attached at their ends to two anchors that will keep them at the bottom, which allowed them to stay in the defined place and a surface buoy was used to recognize the place where they were they found the traps, which were attached to the mother line by the orinque.

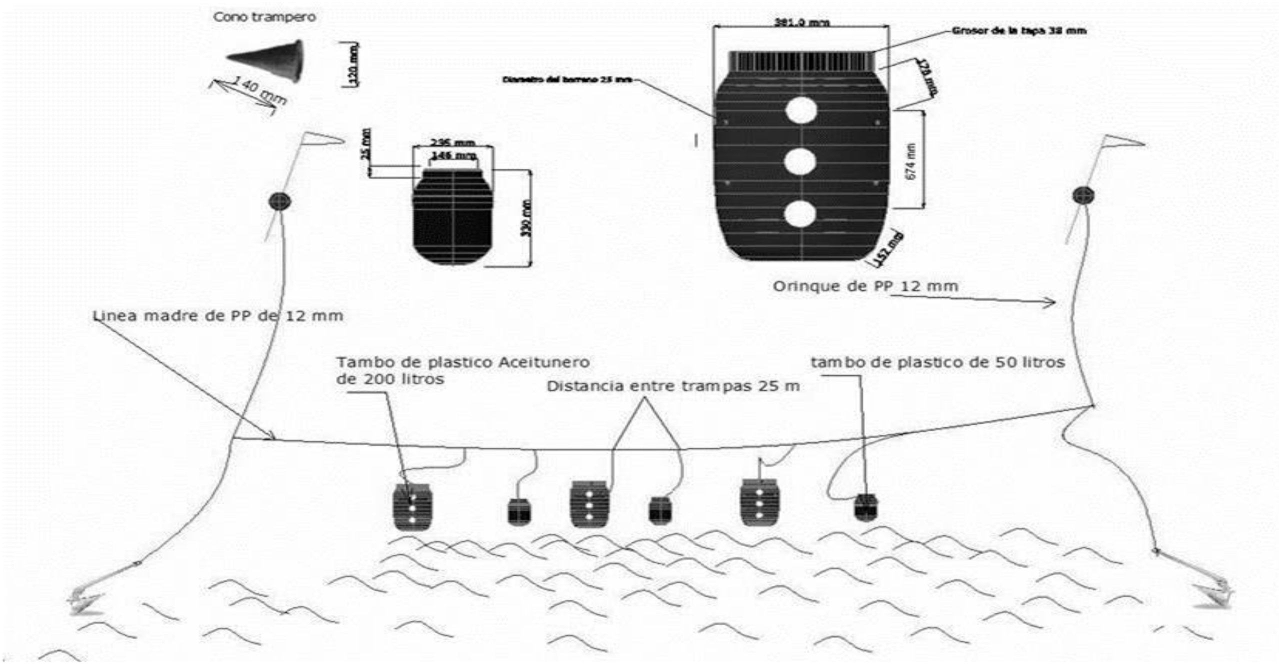

Fig. 2 Scheme of the experimental longline line for catching Pacific hagfish.

180 traps with bait and another line of 180 traps without bait were placed in the line, to act as targets, which were analyzed to see if it was the bait that urged these animals to enter the trap, or were they only looking for a type of protection in the area where they live.

2.3 Historical Facts

To obtain the data to be compared with the current ones, the databases of the 2010 and 2011 fishing seasons were used. In order for the data to correspond to the same period as the current one, only the data obtained in the months from March to July.

2.3.1 Catch per unit effort of the hagfish (E. stoutti) (CPUE kg/trap).

To analyze the distribution of the painted witch (E. stoutti), the equation (I) of capture per unit effort CPUE (kg/trap) was used. The catch per unit effort formula used is:

$$CPUE = \frac{\sum_{i=1} CT_i}{n\ trap}$$

Where, CT = is the total catch in kg,

n trap = are the number of traps used in each of the fishing operation.

2.3.2 Statistical Comparison

Finally, with the support of the statistical software

Past 4.03 [13], comparative tests will be carried out to determine if there are significant differences between the Catch per Unit Effort calculated between the years of interest in this study.

3. Results and Discussion

3.1 Structure of the Population and Sizes

The sizes of 1619 mixinids captured in the period 2010, 2011 and 2021 were determined (Fig. 3a and b). The analysis was carried out considering all the frequency groups (females and males) for the total catch. Most of the fish (66%) measured between 35 and 52 cm, while 6% were greater than 52 cm and 28% were less than 35 cm. Five groups were identified in the sample, whose modes were: 16.4, 27.6, 36, 46, and 54 cm, respectively. The total length (Lt) was found between 21.5 and 59.5 cm, but can reach up to 63 cm, with an average of 40.5 cm.

3.2 Monthly Length-Weight Relationship

A high correlation is observed since a determination coefficient (R2) of 0.738 was presented in the function P = 0.00013764Lt (2.3115) where P is weight and Lt is total length (Fig. 3c).

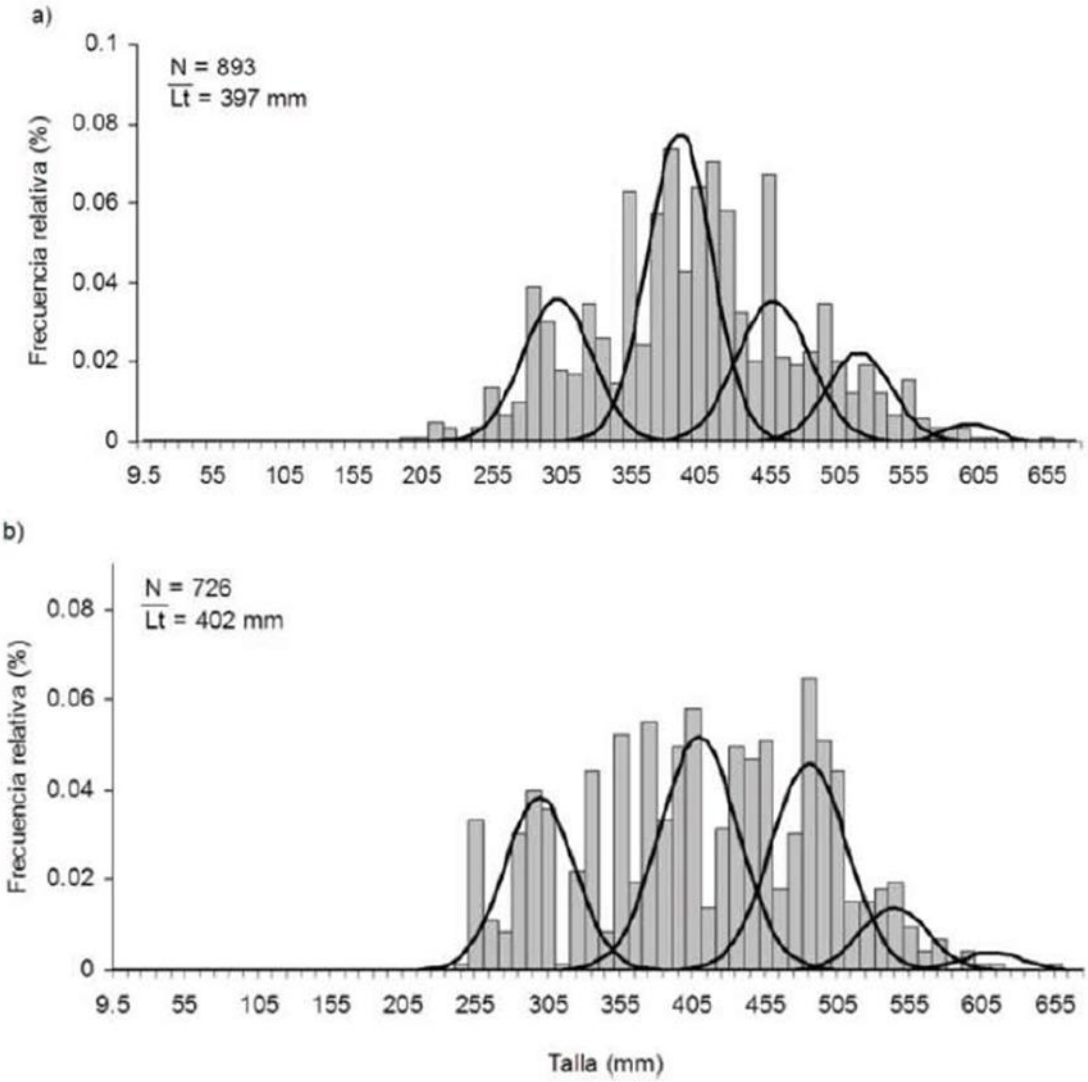

Fig. 3 a) and b) Zise structure of the hagfish Fishery.

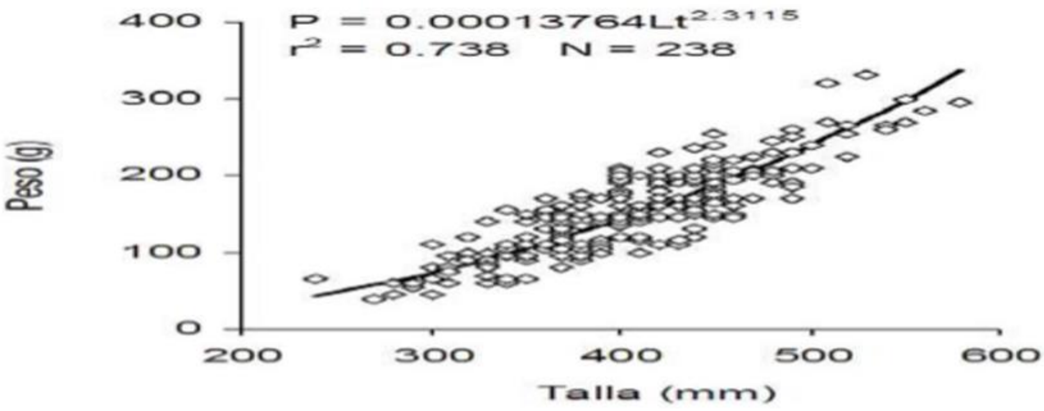

Fig. 3c Length-weight ratio of the hagfish.

After many years of the cessation of commercial extraction of E. stoutii, it has been possible to capture again through the use of traps during the months of March to July 2021, registering a total capture of 19,604 kg of production during that period, with an effort 9,650 traps distributed in 29 fishing sets. An amount less than that obtained during the same period in both 2010 and 2011 (Fig. 4a).

With the catch data and the number of traps used, the catch per unit effort was calculated, resulting in an average of 2,013 kg/trap for this year; In the same period but from the last 2 seasons, 0.702 kg/trap was obtained in 2010 and 1.041 kg/trap in 2011 (Fig. 4b).

Table 1 shows the detail of the fishing effort used during the study period in the 3 years in comparison. Where it can be seen that the highest catch was obtained in April 2011 with 7,695 kg, while the lowest was during the same month but this year. Regarding the effort, the highest number of traps used was 9,700, both in June 2010, while the lowest was 1,200 traps also in the month of April but in the current year 2021.

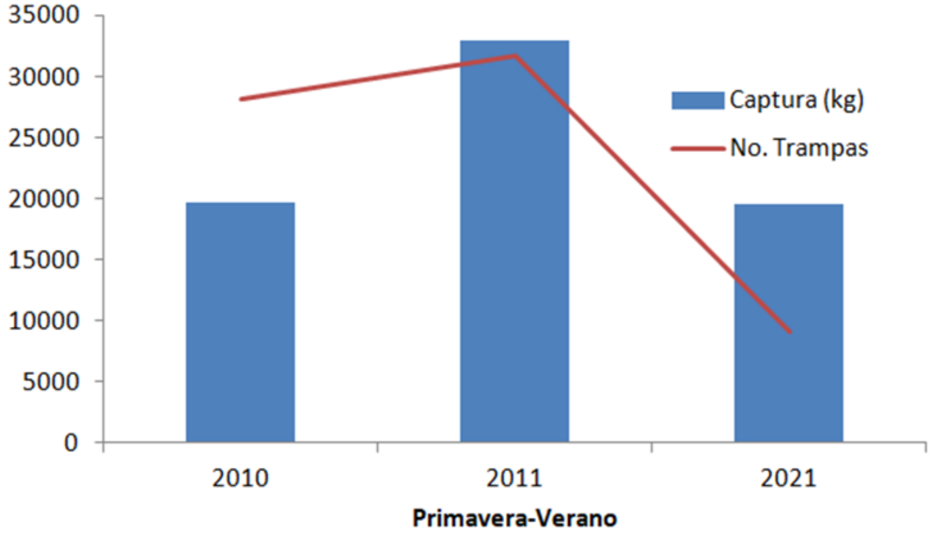

Fig. 4a Comparison of the catch obtained in the spring of 2010, 2011, 2021 with the number of traps used to obtain those catches in the mentioned period.

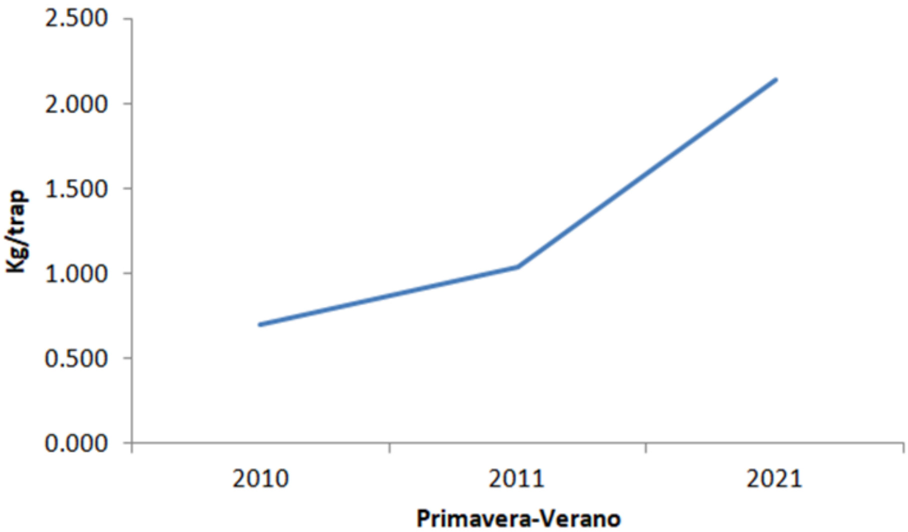

Fig. 4b Catch per unit effort obtained in the first quarter of spring 2010, 2011, 2021.

Table 1 Details of the total fishing effort used in the months of March, April and May during the spring in 2010, 2011, 2021.

	Marzo			Abril			mayo			junio			Julio		
	Lances	Trampas	Captura	Lances	Trampas	Captura	Lances	Trampas	Captura	Lances	Trampas	Captura	Lances	Trampas	Captura
2010	18	5,400	2,776	34	7,850	4,037	13	2,950	2,015	43	9,700	8,440	10	2,250	2,480
2011	13	2,340	2,510	40	7,200	7,695	40	7,200	7,425	43	7,740	8,260	40	7,200	7,075
2021	10	1,500	2,430	8	1,200	1,995	11	1,650	3,969	23	3,450	8,400	9	1,350	2,810

Regarding the catch per unit effort in this same period, the lowest recorded was in March and April 2010 with 0.514 kg/trap, while the highest was recorded in June 2021 with 2.435 kg/trap (Fig. 5).

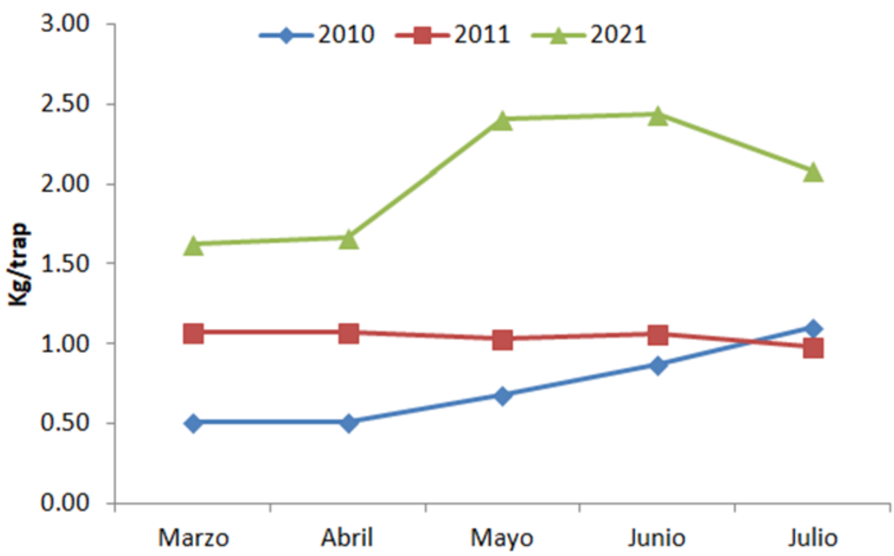

Fig. 5 Average catch per trap obtained during the period from March to May of the 2010, 2011 and 2021 seasons.

Finally, regarding the statistical comparison of the capture per unit effort calculated, due to the characteristics of the data, it was decided to use the Kruskall-Wallis test, where it was found that there were significant differences between the means of the samples; To determine in greater detail the differences between the data, a Mann-Whitney matching test was carried out, in which it can be observed that there are no significant differences between the 2010 and 2011 data ($p = 0.1425$), on the other hand, the test did find significant differences between the data from 2021 and those from previous years (p = 0.0121).

4. Discussion

In Mexico, exploratory fishing for hagfish represents an opportunity to develop a new activity that could provide sources of regional employment. However, the fishery is still in the development stage and the government agency is systematically collecting relevant abundance and biology data to ensure that there is a sustainable fishery. The data analyzed in our study, as part of the exploratory fishery, represent a virgin population since there was no previous exploitation of hagfish in the region. Furthermore, there are no records of bycatch of hagfish in other fisheries that represent a source of fishing mortality. Although we believe that the trap has some size selection, only small individuals are not represented in the CPUE reported in the study.

During the early development of this exploratory fishery (2006-2008), the reported length structure for the mixinid ranged between 13-65 cm TL with an average of 39.3 cm TL [10]. In the study reported by Marquez-Farias et al. (2016), the size range reported in this study was 32 to 59 cm TL with an average of 43.3 cm TL. The parameters of the weight-length relationship reported by Flores-Olivares et al. (2009) [10]. In the study reported by Marquez-Farias et al. (2016) for the mixinid in the same area were a = 0.033 and b = 2.3, which represents negative allometric growth. These same authors estimated the arithmetic mean of the monthly catch against a robust estimator using the delta distribution [14]. Since they did not observe sets with zero catch and the distribution of catch frequencies per month observed was homogeneous, we did not detect differences between the arithmetic mean and the delta estimator.

Regarding the fishing yield, it is reported by Benson et al. (2001) [12], for E. stoutii in the British Columbia area and for the 2000-2001 fishing season, the CPUE of 1.1 kg/trap up to 0.44 kg/trap. Likewise, Wayne (1994), reports for the California E. stoutii fishery, CPUEs that fluctuated from 1.3 kg/trap to 0.06 kg/trap. In the case of the results reported in this study, the yields in the last year have been very stable, fluctuating from 2.4 kg/trap to 1.62 kg/trap, which speaks well of the yields that have been maintained, without any symptoms. of current concern about the decline of the fishery.

Under this judgment, the catch of the hagfish fishery remains within healthy limits, since yields have not dropped below 1.0 kg/trap [6], but we must consider this CPUE measure as an important measure. for the determination of an index of abundance capable of announcing the need to adjust the authorized fishing effort in the event of a possible commercial fishing.

The exploratory fishery for hagfish is in an evaluation phase to determine the exploitation potential of the stock in northwestern Mexico. At this point, it is not yet possible to identify the potential level of allowable fishing effort that the stock could sustain. Defining the level of exploitation of the hagfish is a challenge because the population-recruitment relationship for this group of species is still unknown. The systematic monitoring of the proportion of mature fish and the fecundity of females are identified as priority lines of research. This is particularly important when a time series of effort and catch data is lacking. Examples of hawk fisheries that have declined in individual regions indicate that, in general, hagfish populations have shown little resistance to fishing [9].

5. Conclusions

After almost a decade without commercially capturing this resource, it is confirmed that the fishing method can still carry out the extractive work that can exceed 1 kg/trap.

The marked increase in current fishing yields with respect to those of a decade ago, makes us consider the possibility of a recovery of the fishing stock available in the study area.

The studies carried out to date through the information obtained as a result of the promotion fishing has contributed to generate the first sustainability indices and its fishing technological development, necessary to bring the fishery to a commercial level in the near future in accordance with the established guidelines by CONAPESCA.

However, it is necessary to continue carrying out studies and tests in such a way that the biological and fishery information of the resource can be updated after such a long time of cessation in the fishery.

References

[1] A. J. Clark and A. P. Summers, Morphology and kinematics of feeding in hagfish: possible functional advantages of jaws, *Journal of Experimental Biology* 210 (2007) 3897-3909.

[2] J. E. Mclnerney and D. O. Evans, Habitat characteristics of the Pacific hagfish, Polistotrema stoutii, *Journal of Fisheries Research Board of Canada* 27 (1970) 966-968.

[3] E. W. Johnson, Aspects of the biology of Pacific (Eptatretus stouti) and black (Eptatretus deani) hagfishes from Monterrey Bay, California, M.S. thesis, California State University, 1994.

[4] E. J. Wayne, Aspects of the biology of Pacific (Eptatretus stoutii) and black (Eptatretus deani) hagfishes: From Monterrey Bay, California, M.S. thesis, California State University, 1994.

[5] K. D. Leask and R. J. Beamish, Review of the fisheries and biology of the Pacific hagfish (Eptatretus stoutii) in British Columbia, with recommendation for biological sampling in a developmental fishery, *Canadian Stock Assessment Secretariat Research Document* 99/205 (1999) 1-47.

[6] W. Barss, Pacific hagfish Eptatretus stouti, and black hagfish E. deani. The Oregon fishery and port sampling observations, 1988-1992, *Marine Fisheries Review* 55 (1993) (4) 19-30.

[7] R. Nakamura, Growth and age study of Pacific hagfish (Eptatretus stoutii) off the central California coast: National Marine Fisheries Service, Saltonstall-Kennedy Research Grant NA27FD0169-01 Final Report, Monterey, CA, USA: Department of Fish and Game, 1994.

[8] B. M. Leaman and M. Stocker (Eds.), Ground fish stock assessments for the west coast of Canada in 1992 and recommended yield option for 1993, *Canadian Technical Report of Fisheries and Aquatic Sciences* 1919 (1993) 1-407.

[9] J. E. Ellis, S. Rowe and H. K. Lotze, Expansion of hagfish fisheries in Atlantic Canada and worldwide, *Fisheries Research* 161 (2015) 24-33.

[10] J. Flores, O. Vargas and M. Quiroz, Capturas de Eptatretus stoutii frente a la costa noroccidental de Baja California, México, 2006-2008, *Ciencia Pesquera* 17 (2009) (2).

[11] F. Arreguín-Sánchez, Pesquerías de México: (Diagnóstico y Perspectivas), in: P. Guzmán-Amaya & D. Fuentes-Castellanos (Eds.), *Pesca, Acuicultura e Investigación en México*, Cámara de Diputados, LIX Legislatura/Congreso de la Unión, México, 2006, pp. 13-36.

[12] A. J. Benson, C. M. Neville and G. A. McFarlane, An update for the British Columbia experimental fishery for Pacific hagfish (Eptatretus stoutii), Department of Fisheries and Oceans Canada, Pacific Biological Station, British Columbia, Canada, 2001.

[13] O. Hammer, D. A. T. Harper and P. D. Ryan, PAST: Paleontological Stadistic software package for education and análisis, *Paleontologia Electronica* 4 (2001) (1) 9.

[14] M. Pennington, Estimating the mean and variance from highly skewed marine data, *Fishery Bulletin* (1996) 94-505.