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SC9-SQ04

Squid On Board Monitoring Results

Peru

Main results of the biological and fisheries monitoring of the jumbo flying squid *Dosidicus gigas* on board the artisanal fleet dedicated to its capture in Peruvian jurisdictional waters, which could also be extended to the area of application of the SPRFMO Convention

by

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This report contains information on the jumbo flying squid stock and fishery in Peruvian jurisdictional waters that, we reiterate, the delegation of Peru, in use of its discretionary powers, voluntarily provides for the purpose of information and support to the scientific research work within the Scientific Committee of the SPRFMO. In doing so, while referring to Article 5 of the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean and reiterating that Peru has not given the express consent contemplated in Article 20 (4) (a) (iii) of the Convention, Peru reaffirms that the decisions and conservation and management measures adopted by the SPRFMO Commission are not applicable within Peruvian jurisdictional waters.

IN MEMORIAM

This report is dedicated to the Fisheries Engineer and Doctor in Environment and Sustainable Development **Luis Mariátegui Rosales "Lucho"** (05.30.1953 - 12.17.2020), who unexpectedly left for eternity on 17 December 2020, while preparing for his participation as a member of the Peruvian delegation at the 9th annual meeting of the Commission of the South Pacific Regional Fisheries Management Organization (SPRFMO), which was held from 26 January to 5 February 2021. This document presents the results of Lucho's observations, notes and initiatives to improve the monitoring of the jumbo flying squid *Dosidicus gigas* fishery in Peruvian jurisdictional waters based on his vast field experience. Lucho participated as a scientific observer on board the foreign industrial jigger fishing vessels that, through fishing licenses granted by the Peruvian Government, fished for jumbo flying squid in Peruvian waters between 1991 and 2011. He participated as a researcher in numerous national and international marine resources scientific research and stock assessment surveys, and was a member of various scientific working groups, including groups dedicated to study the jumbo flying squid. It is worth noting his active role as a representative of the Instituto del Mar del Perú (IMARPE) in the Peruvian group that participated in the annual meetings and intersessional activities of the SPRFMO Commission and its Scientific Committee. Our great appreciations and gratitude for your work and contribution to fisheries science in Peru. Until forever, Lucho.



Luis Mariátegui on board the Japanese squid fishing vessel HAKUREI MARU No. 8 measuring one of the largest specimens of jumbo flying squid *Dosidicus gigas* ever caught in Peruvian waters (a female squid of 127 mm mantle length, caught at 01:00 hours on 12 January 2011 at latitude 15°29.462 S and longitude 78°25.128 W, and sea surface temperature of 22.6°C). This and three other jumbo flying squids captured during the same exploratory fishing trip were sent on 2011 for necropsy and display to the “Museo del Calamar Gigante” (Giant Squid Museum), in Lueca, Asturias, Spain.

SUMMARY

Reference is made to the abundant and valuable data and information that was collected through IMARPE scientific observers on board the large industrial squid fishing vessels that operated in Peruvian jurisdictional waters between 1999 and 2011. This contributed significantly to improve the current knowledge on the biology and fishery of the jumbo flying squid *Dosidicus gigas* in Peruvian jurisdictional waters and the adjacent high seas, as well as on its environmental preferences and interactions. Since 2012, all the jumbo flying squid catches in Peruvian waters are made by a large fleet of (more than 4 000) small artisanal fishing vessel. Since the operations of the large industrial fleet ceased, IMARPE developed a monitoring system for the jumbo flying squid fishery that included on-land as well as on-board observers to monitor the catches and fishing activities of the artisanal fleet. This on-board monitoring has been operational since September 2015 and this paper describes the main results of the observations made during this on-board monitoring of the artisanal jumbo flying squid fishery in Peruvian jurisdictional waters. The usefulness and feasibility of operating this type on-board monitoring system in Peruvian jurisdictional waters is highlighted, and the case is made that, with some minor adjustments, this on-board monitoring system being run by IMARPE can be expanded as needed, to achieve a larger coverage of artisanal vessels, including those that eventually may be authorized and start fishing for jumbo flying squid in the adjacent high seas, in the SPRFMO Convention area. It is also concluded that this IMARPE on-board monitoring would satisfy some of the main requirements set forth for artisanal fishing vessels less than 15 meters in paragraph 4 of the SPRFMO conservation and management measures CMM 16-2021 (SPRFMO Observer Programme).

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1. INTRODUCTION

The jumbo flying squid *Dosidicus gigas* is the main commercial marine invertebrate being exploited in Peruvian jurisdictional waters since the early 1990s. At first, catches of this species in Peruvian waters were mainly carried out by large industrial squid jigging vessels from Japan and Korea operating under Peruvian license agreements. As part of these license fishing agreements, all the industrial jigger vessels fishing for jumbo flying squid in Peruvian waters were subject to certain obligations. One of which was to always carry a Peruvian scientific observer on board and provide them with all the logistic and operational facilities (including transportation, accommodation and food on board, access to the bridge and fishing deck, access to the catch and all catch data, etc.) for the fulfillment of their research and fisheries monitoring tasks. Which included collecting and reporting rather detailed biological and fisheries data and information regarding all on board fishing activities under the directives of the Instituto del Mar del Perú (IMARPE).

The abundant and valuable data and information was collected through these on-board observers contributed significantly improving our knowledge on the biology and fishery of the jumbo flying squid in Peruvian jurisdictional waters and the adjacent high seas, as well as on its environmental preferences and interactions, as is reflected in part of the abundant scientific literature on the jumbo flying squid fishery and biology made available by IMARPE to the scientific community (*e.g.*, Alegre *et al.* 2014, Argüelles & Tafur 2010, Argüelles & Taipei 2018, Argüelles *et al.* 2017, Csirke *et al.* 2015, 2018, Guevara-Carrasco *et al.* 2018, Keylf *et al.* 2008, Mariátegui *et al.* 2018, Tafur *et al.* 2001).

Since 2000, the role of the artisanal fleet in the squid fishery increased rapidly year after year. At first it acted simultaneously with the industrial fleet, but with some spatial separation that was established to avoid or reduce potential conflicts between the two fleets. While the coastal areas were reserved for the artisanal fleets, the industrial jigger vessels were initially authorized to operate only beyond 20 nm from the coast, and this distance increased to 80 nm by 2011, until the license agreements that allowed foreign fishing vessels to fish for jumbo flying squid in Peruvian waters ceased by the end of 2011.

Until 2011, fishery information and data were collected from both fleets, on board from the industrial fleet and at landing sites from the artisanal fleet. The information and data collected in the landing sites included the total catch, number of fishermen on board, estimated location of the main fishing ground and number of fishing days per vessel-trip. This data from the artisanal fishery continued to be collected after 2011 and continues to be collected to date.

However, without the industrial jigger fleet, the flux of the more detailed information and data that used to be collected by the on-board scientific observers also ceased. Therefore, more specific information on catch and fishing effort (*e.g.*, on total catch in weight and/or in numbers, and on hours fished and number of fishermen per set or fishing operation, etc.) and on the squid being caught (*e.g.*, on the length-frequency distribution and other biometric and biological characteristics) were lacking. In this regard, it is noted that jumbo flying squid is usually gutted at sea shortly after capture, and most if not all the squid landed by the artisanal fleet is gutted, and the amount and quality of the biological information that can be collected from gutted specimens is very limited.

To tackle this lack of important fishery and biological information and data, the Instituto del Mar del Perú (IMARPE), with a special funding allocation from the Peruvian Ministry of

Production (Ministerio de la Producción, PRODUCE), initiated since the third quarter of 2015 a project for "Strengthening the scientific basis for the development of the jumbo flying squid fishery". One of the objectives of this project was to strengthen the biological and fisheries monitoring of the artisanal jumbo flying squid fishery by deploying a limited number of observers on board artisanal vessels fishing for jumbo flying squid in Peruvian waters. And to fulfill this objective IMARPE hired extra personnel (up to 13 at a given time-period) that after a short training as on-board observers were deployed to the main jumbo flying squid landing sites to embark for the whole duration of a fishing trip on one artisanal vessel after another, with a short reporting and resting break in between. This activity produced a wealth of data and information on the on-board fishing activities of the artisanal vessels as well as on the main biological characteristics of the squid being caught in Peruvian jurisdictional waters between 2015 and 2019. These on-board and other field monitoring activities were suspended or drastically since March 2020 due to the Covid-19 related restrictions, some of them have been partially reinitiated in recent months and IMARPE remains ready reinitiate them in full as soon as it be safe and Covid-19 related restrictions are lifted.

The results obtained between 2015 and 2019 from this on-board monitoring activity demonstrate the feasibility and usefulness of placing trained observers on board artisanal vessels fishing for jumbo flying squid, even if the coverage of the total artisanal fleet (more than 4 500 vessels) fishing for jumbo flying squid in Peruvian waters has been very low (on average less than 1%). Nevertheless, this paper presents the main results of the observations made during the monitoring of the artisanal jumbo flying squid fishery in Peruvian jurisdictional waters through IMARPE's on board observers, with clear indications and suggestions that with some minor adjustments this on-board monitoring system can be expanded to achieve a larger coverage of artisanal vessels, including those that eventually may start fishing for jumbo flying squid also in the adjacent high seas, in the Convention area.

2. MATERIAL AND METHODS

Every scientific observer who embarks on board an artisanal squid fishing vessel is supplied with the appropriate forms to report the results of the on-board biometric and biological sampling and of the catch and effort observations. In addition, they are provided with a portable satellite global positioning system (GPS), measuring tape, dynamometer or portable scale, dissecting equipment and stationery. In addition, they may be provided with additional materials for collecting squid stomachs, statoliths and various tissues.

The catch, fishing effort, position and time of the beginning and end of each set or fishing operation are estimated or measured and recorded. Also, by means of a random sampling, the size-frequency composition (mantle length) and main biological characteristics of the jumbo flying squids caught by day are estimated and recorded. More details of onboard sampling can be found in Tafur *et al.* (2016, 2019) and Yamashiro *et al.* (2018, 2018a).

3. RESULTS

3.1 Fleet geographical distribution

The Peruvian artisanal squid fishing fleet can be divided into two groups according to their base ports and location of their main fishing areas. Artisanal fishing vessels based in northern Peruvian ports usually fish in areas between 5° and 8°S but can move to fishing areas as far south as 16°S during particularly warm periods, as observed during the strong El Niño of 2015-2016. While artisanal fishing vessels based in southern ports mostly operate in fishing areas

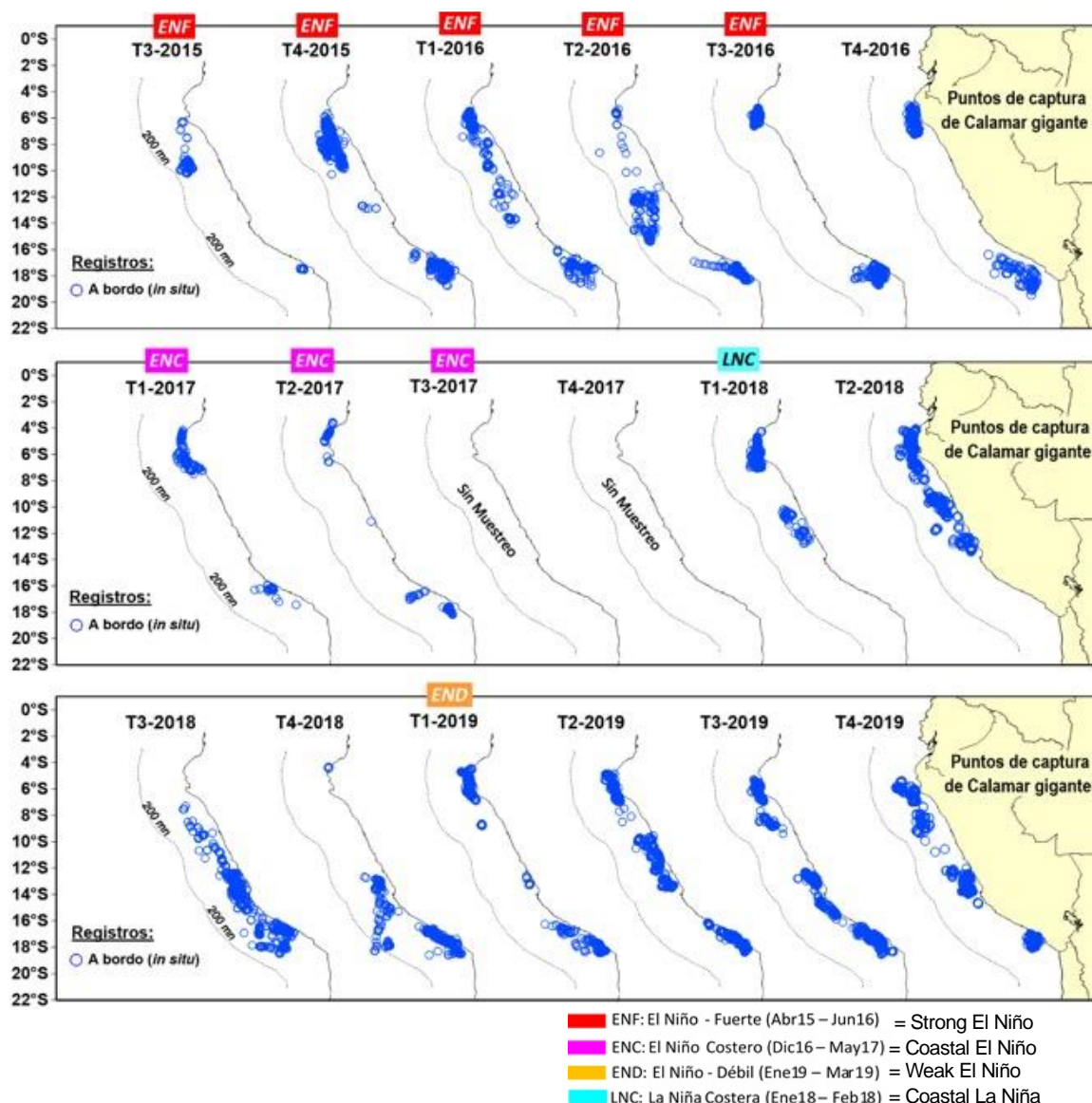


Figure 1.- Geographic distribution of the main fishing grounds of jumbo flying squid as reported by the IMARPE observers on board artisanal squid fishing vessels, by quarter, from the third quarters of 2015 to the end of 2019, with indication of warm (El Niño) and cold (La Niña) periods

located between 16° and 18°S. Both fleets operate mostly within 100 nm, but can reach 200 nm (Figure 1).

3.2. Fishing effort and abundance indices

A total of 87 014 trips of artisanal vessels fishing for jumbo flying squid were registered between 2015 and 2019 by port observers in the landing sites along the Peruvian coast. Of these 87 014 jumbo flying squid fishing trips, 516 trips had a scientific observer on board, representing on average a 0.59% coverage of on-board observation and recording of the fishing operations and biological characteristics of the squid being caught. This coverage varied between 0.24% (in 2017) and 1.03% (in 2018) (Table 1). It is noted that this on-board observer programme started only in September 2015 and that due to a combination of administrative and logistic factors it was temporarily suspended between July and December 2017. During 2020 it operated only during the first two months of the year and since March 2020 it has been suspended until further notice due to Covid-19 related restrictions.

With regards to the fishing effort, the data collected by the on-board observers indicate that the number of days per fishing trip of the artisanal fleet fishing for jumbo flying squid had a

large monthly variation between September 2015 and December 2019. With a minimum average number of fishing days per trip of 2 days in May 2017 and a maximum of 15.7 days in November 2016. With some noticeable differences between the fleets that mostly operate in the north and those that operate in the south. Where it is worth noting that during the period September 2015 to May 2016 (during a strong El Niño), the average number of days per trip of the northern fleet are much higher than that of the southern fleet (Figure 2), while the average number of days per trip of the northern fleet are lower than the southern fleet during the period September 2016 to February 2017 (during neutral environmental conditions and the initial phase of a moderate-coastal El Niño).

Table 1.- Number of jumbo flying squid fishing trips by artisanal fishing vessels recorded in the landing sites and number of fishing trip with on-board observers recording biological and fisheries information and data, by fleet location and by year, years 2015-2019

Years	Number of fishing trips recorded in the landing sites	Coverage of fishing trips with on-board observes, in numbers and in percentage			
		North fleet	South fleet	Total	Percentage
2015	21 041	37	21	58	0.28%
2016	17 047	75	74	149	0.87%
2017	14 055	27	7	34	0.24%
2018	12 582	99	30	129	1.03%
2019	22 289	87	59	146	0.66%
Total	87 014	325	191	516	0.59%

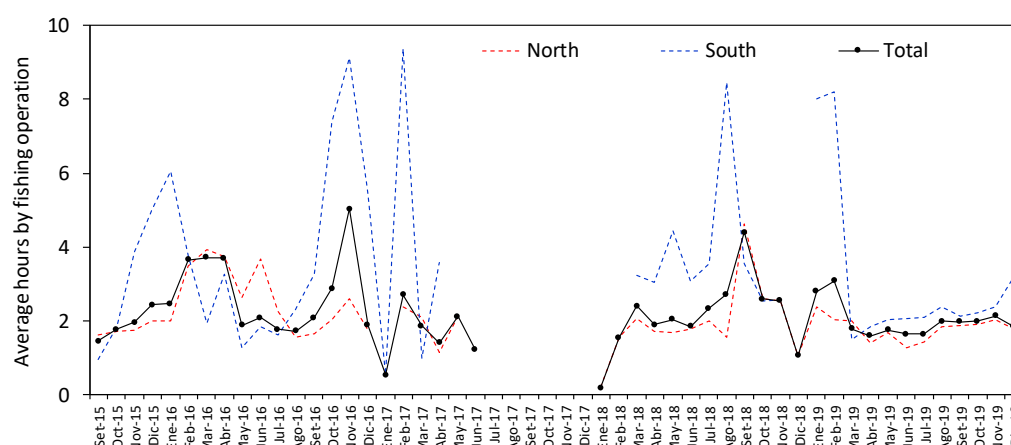


Figure 2.- Monthly average hours per fishing day aboard the jumbo flying squid artisanal fishing vessels as recorded by onboard scientific observers, by fleet location, between September 2015 and December 2019

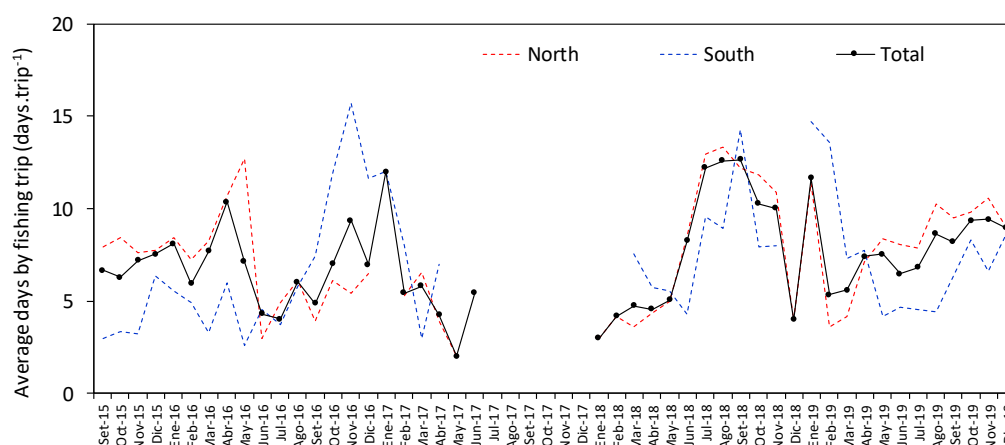


Figure 3.- Monthly average number of days per fishing trip of the jumbo flying squid artisanal fishing vessels recorded by onboard scientific observers, by fleet location, between September 2015 and December 2019

During the same period, the observed average number of hours per set or fishing operation varied between 0.2 (in January 2018) and 9.4 (in February 2017) (Figure 3). By fleet location the average number of hours per set or fishing operation is generally higher in the southern fleet, which varies between 0.5 and 9.4 hours, with an average of 3.5 hours; while in the northern fleet this varies between 0.2 and 4.6 hours, with an average of 2.1 hours.

Then, for the same period, the nominal CPUE has monthly average values ranged between 0.01 and 144.9 kg/hour-fisherman (Figure 4). With the higher CPUE values for the totals of both fleets in October 2015, July 2016, and June 2018. A slight but continuous decreasing trend is observed between January and December 2019.

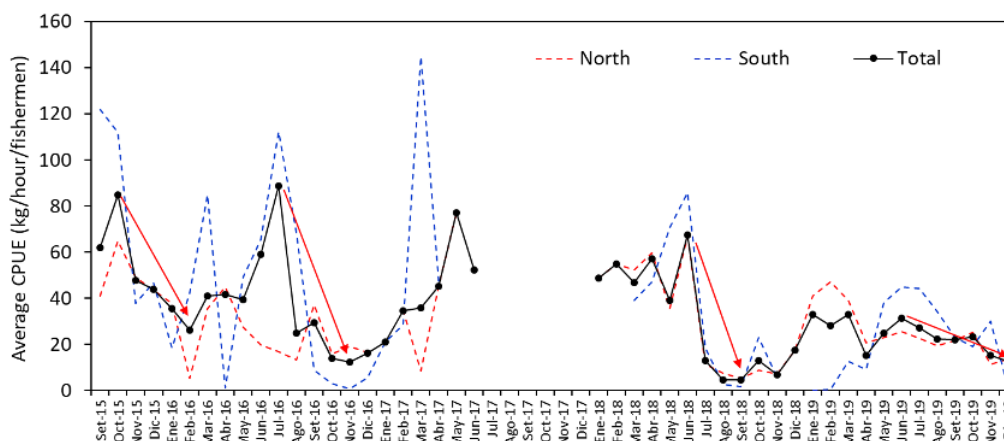


Figure 4.- Monthly average nominal CPUE (in kg/hour-fishermen) in the artisanal jumbo flying squid fishery, as recorded by onboard scientific observers, by fleet location, between September 2015 and December 2019

3.3. Size frequency distribution and gonadal maturity stages

Between 2015 and 2019, a total of 172 097 specimens of jumbo flying squid were sampled by IMARPE on-board scientific observers to determine the biometrical and biological characteristics of the jumbo flying squid caught by the artisanal fleet during those years. The observed size of those squid specimens sampled ranged from 17 to 118 cm mantle length (ML) and the observed average size per year varied between 50.2 and 76.2 cm ML for females and between 51 and 75.5 cm ML for males.

Some differences in the annual size-frequency distributions of 2015-2019 are worth noting (Figure 5). In the 2015 and 2016 size-frequency distributions the range of sizes are broader, the mean size is larger and at least two modal sizes can clearly be observed. While in 2017, 2018 and 2019 the mean sizes were smaller and the size frequency distributions were narrower and mostly unimodal.

With regards to gonadal maturity, the results of the on-board biological sampling indicate that during 2015 and 2016 there was a predominance of mature stages both in females and males. While during 2018 and 2019 there was a predominance of maturing stages in females, and almost equal predominance of maturing and mature stages in males (Figure 6). As noted earlier, no data was collected during the main part (September-December) of the 2017 squid reproductive cycle.

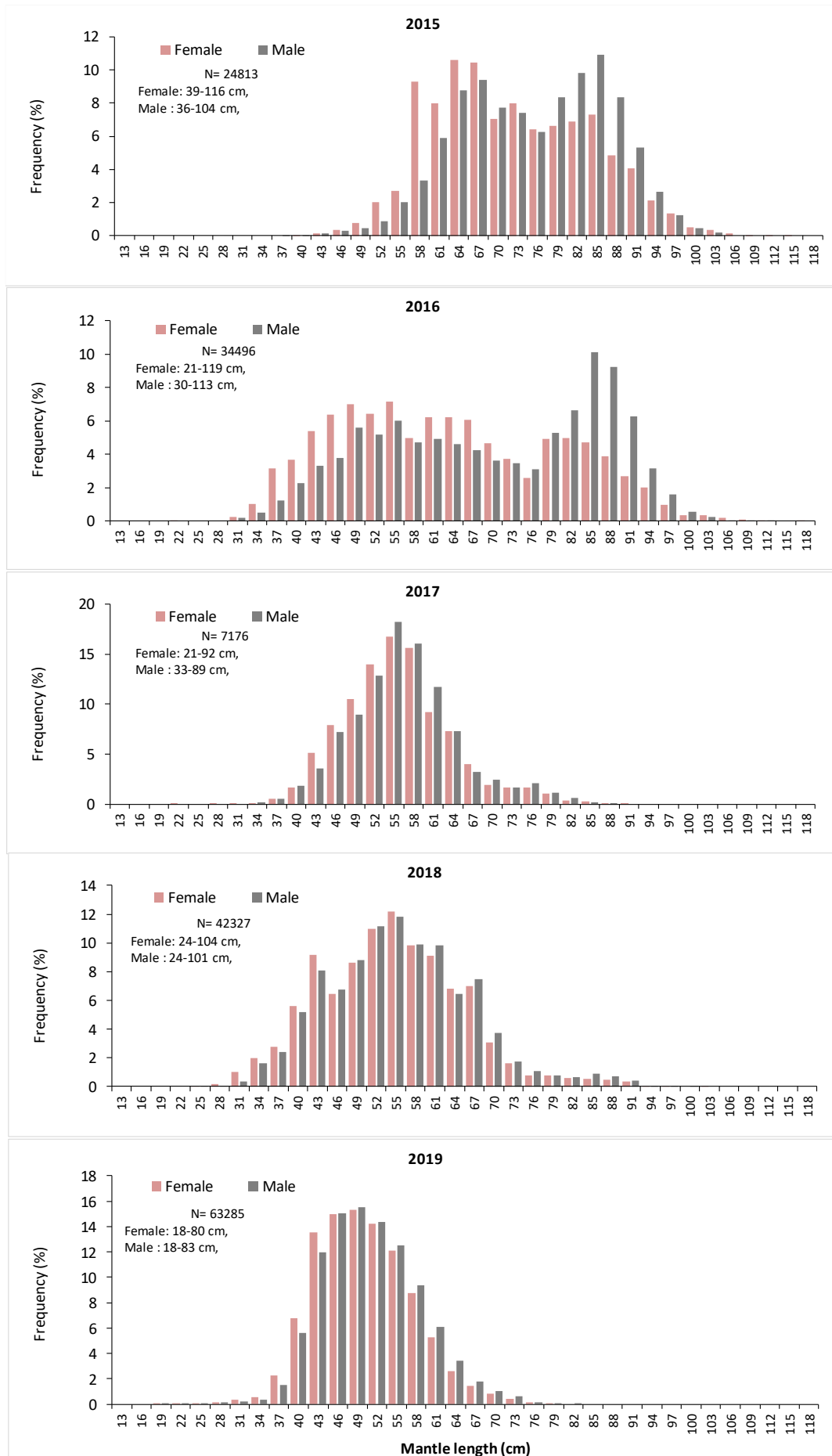


Figure 5.- Size-frequency distribution (mantle length in cm), by year and by sex, of jumbo flying squid caught by the artisanal fleet as recorded by IMARPE on-board observers, years 2015-2019

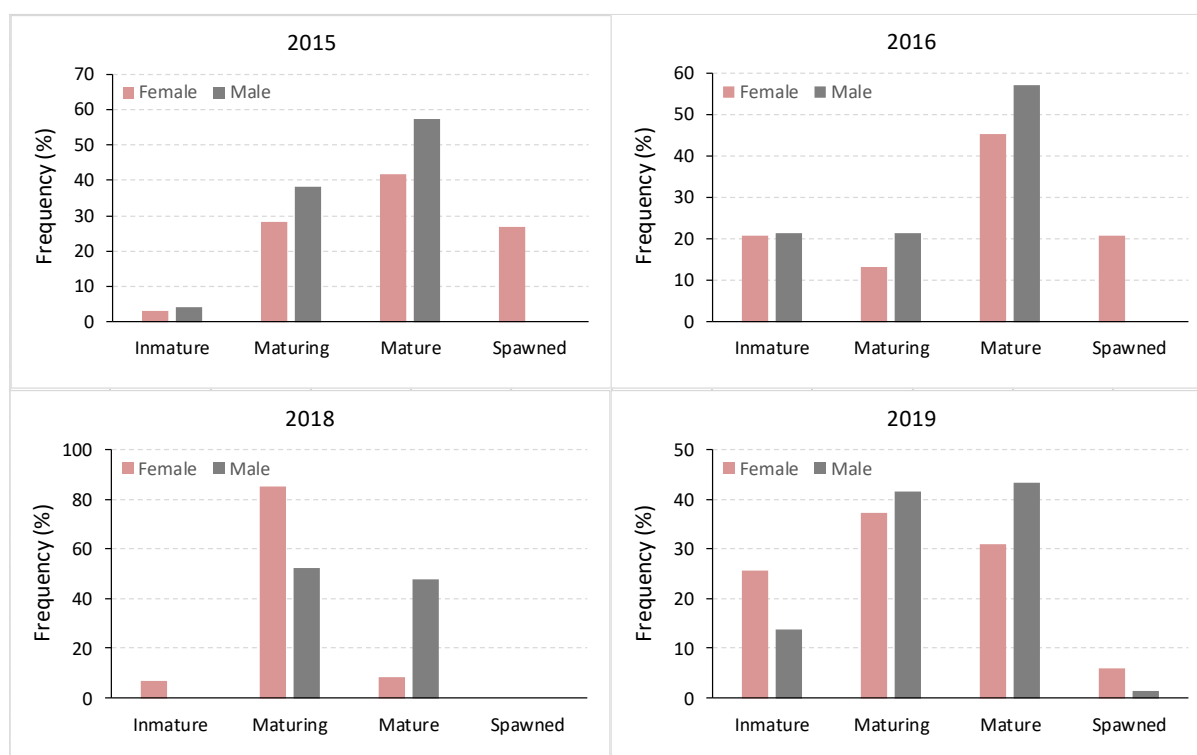


Figure 6.- Gonadal maturity stages by year and by sex, of jumbo flying squid of jumbo flying squid caught by the artisanal fleet as recorded by IMARPE on-board observers, years 2015-2016 and 2018-2019

4. MAIN CONCLUSIONS

The coverage of the biological and fisheries data and information of the catches and fishing activities of the artisanal fleet fishing for jumbo flying squid achieved between 2015 and 2019 through on-board observers appears to be low, since, in general, there have been on board observers in less than 1% of the total fishing trips per vessel that have been recorded in the landing sites. However, it is worth noting that this low percentage coverage of the "on board" observations is largely due to the large number of (more than 4 000) artisanal vessels that actively participate in the jumbo flying squid fishery in Peru and, also, that the monitoring through "on board" observations is complemented with a more capillary "on land" coverage by observers in the landing sites.

In this regard, it is noted that the observers in the landing sites recorded the catch and fishing activities of a total of 87 014 fishing trips during the 5 years considered, of which a total of 516 fishing trips have been directly monitored by onboard observers, with an average of 103 fishing trips per year. It is also worth noting that the on-board observers are strategically located along the coast to ensure an adequate coverage of all the main fishing areas visited by the fleet.

It is also highlighted that abundant and useful fisheries and biological information and data has been obtained during these 516 fishing trips monitored in situ by on board observers. Including details of the location, duration and number of participating fishers per trip; the sex and size of a total of 172 097 jumbo flying squids sampled from the total catch; sub-samples to determine their stage of gonadal maturity; as well as other information and samples of stomach contents, body tissue, statoliths, etc.

The type, quality and quantity of observations made during these 5 years demonstrate the usefulness and feasibility of regularly gathering biological and fisheries information and data through observers aboard artisanal vessels fishing for jumbo flying squid in Peruvian jurisdictional waters. And the experience accumulated with this on-board monitoring system indicates that, with some slight adjustments, this monitoring system with on-board observers can be extended, even with a broader coverage, to the operations that these same artisanal vessels could eventually carry out on the high seas, in the area of application of the SPRFMO Convention. It is expected that this would satisfy some of the main requirements set forth for or artisanal fishing vessels less than 15 meters in paragraph 4 of the SPRFMO conservation and management measures CMM 16-2021 (SPRFMO Observer Programme).

Some of the abovementioned slight adjustments being considered include:

- (a) increase the number of scientific observers available to embark on artisanal vessels fishing for jumbo flying squid;
- (b) give certain preference to the embarking on board observers in those vessels that are authorized and set sail to fish for jumbo flying squid more than 200 nm from the coast, in the area of application of the Convention;
- (c) coordinate and make the appropriate legal and logistic arrangements to adapt, adopt, disseminate and extend the use of a portable traceability application, such as “TrazApp” (<https://www.trazapp.org>) that has been developed by the NGO World Wildlife Foundation (WWF), is already being used aboard a selected group of artisanal fishing vessels in Peru and allows skippers and/or master-fishers to record on-line information on the catch, position, fishing effort, etc., of each fishing operation; and,
- (d) coordinate and make the necessary arrangements allow observers at the landing sites to have access to and carry out biological sampling of whole specimens (not eviscerated) from part of the fleet, giving particular attention to those vessels that may fish for jumbo flying squid beyond the 200 mn from the coast.

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