SPRFMO
South Pacific Regional Fisheries Management Organisation

11th MEETING OF THE SCIENTIFIC COMMITTEE

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Determination of size ranges by phenotypic group of ***D. gigas*** in Peruvian waters, based on the size-maturity analysis

Republic of Peru

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Determination of size ranges by phenotypic group of *D. gigas* in Peruvian waters, based on the size-maturity analysis

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.

2023

SUMMARY

It is known that in the area of distribution of *D. gigas* in the Southeast Pacific we can find up to three population groups with different biological characteristics. However, population assessment exercises of *D. gigas* in the Southeast Pacific are being carried out considering the hypothesis of a single stock, since up to now there is no robust information available during the 2000s that allows these groups to be separated geographically. In this sense, this document presents fragmentary information from investigations carried out in waters off Peru and Chile outside 200 nm, and shows evidence that shows biological differences of *D. gigas* in the coast-ocean direction. In addition, it presents how to separate these groups, for which mention is made of the need to collect biological information in fishing areas outside 200 nm.

Determination of size ranges by phenotypic group of *D. gigas* in Peruvian waters, based on the size-maturity analysis

The adequate identification of stocks or population units, including the possible presence of groups with different phenotypic characteristics that behave as population subunits, is of great importance in the exercise of evaluation of fishing resources, as well as the calculation, formulation, and application of maximum limits of catch and other fisheries management measures (Csirke et al. 2018). This is a task that has been addressed by the SPRFMO for the giant squid resource Dosidicus gigas.

To establish possible geographic areas for assessment of the jumbo squid in the convention area, areas in which the biological characteristics (length-age at maturity, longevity, etc.) of the target resource are the most "constant", this document describes the findings obtained by different authors on the population structure of the giant squid in the convention area and jurisdictional waters. Also, mantle length sizes ranges are proposed, based on gonadal maturity by subgroups, for possible spatial separation and evaluation.

A separate population of D. gigas is known to exist in the South Pacific from the population found in the Northeast Pacific (Sandoval-Castellanos et al. 2007, 2009, 2010; Staaf et al. 2010), but it is unknown how many stocks of D. gigas are found in the vast neritic-oceanic area of the southeastern Pacific in which this species is distributed, and in which catches have been recorded by the Asian industrial fleet in the convention area (Figure 1), and by the national fleets of Chile and Peru in waters within 200 nm.

D. gigas has biological characteristics such as short life, rapid growth, high phenotypic plasticity, and post-spawning death, biological characteristics that determine that its populations present large variations in abundance and phenotypic forms associated with environmental variations (Bazzino 2001).

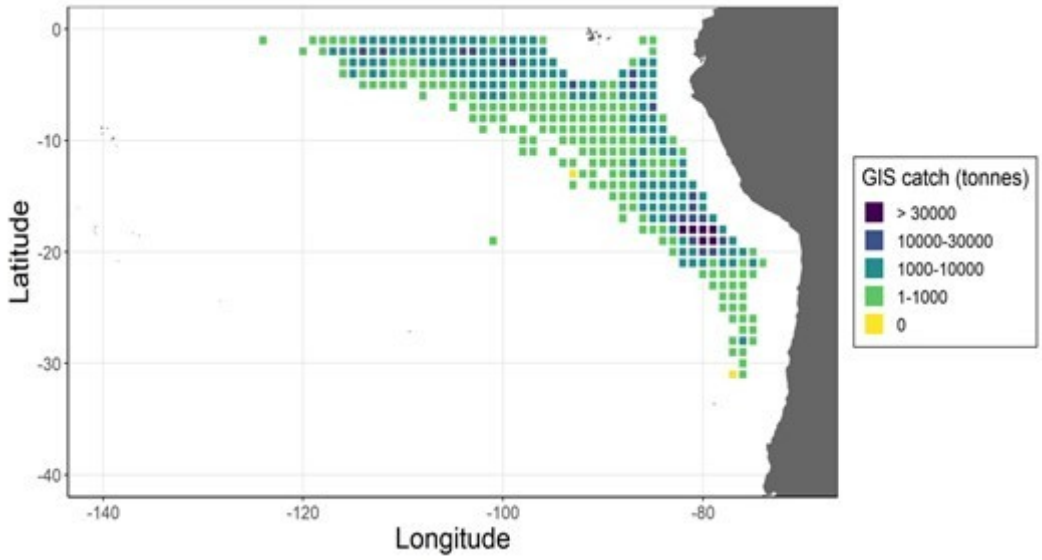

Figure 1. Total Jumbo flying squid catch (tons), across all years and fleets, aggregated to a 1◦ x 1◦ spatial resolution. Taken from SPRFMO Report, Secretariat May 6, 2022

The phenotypic forms in D. gigas have been initially identified by Nigmatullin et al. (2001) (Table 1) and reported in the catches and research carried out in the Peruvian waters since the 1980s (Masuda et al. 1998, Arguelles et al. 2008, Arguelles & Tafur 2010, Arkhipkin et al. 2015, Arguelles et al. al, 2017).

Table 1. Summary table of the groups or possible population subunits of Dosidicus gigas distinguishable by their length at maturity (after Nigmatullin et al., 2001) observed off the Peruvian coast (Modified from Csirke et al., 2018)

Groups by size at sexual maturity	Range of mantle length at adult stage (mm)		Latitudinal distribution range	Longevity (years)
	Males	Females		
Small size	130 to 260	140 to 340	Close to the Equatorial zone (low latitudes)	<1 ?
Medium size	240 to 420	280 to 600	Almost the whole distribution range, except for the high latitudes	~ 1
Large size	400 to 500	550 to 1000	To the north of 10°N, to the south of 10°S and cold waters along the northern and central parts of the Peruvian coast	1.5 to 2

However, in Peruvian waters, these groups appear as separate dominant groups, in different periods (Figure 2) and with a clear spatial separation from their most abundant nuclei, which tend to change sporadically or for periods of one or more decades in the face of environmental changes such as the El Niño, La Niña, El Viejo, and La Vieja (Csirke et al. 2018). While, in areas adjacent to the Peruvian jurisdictional sea, the predominance of the medium size group has been reported (Masuda et al. 1998, Liu et al. 2013, 2013a, Li et al. 2016, 2017). However, the population structure by phenotypic groups is generally unknown in most of the extensive areas of the SPRFMO in which industrial fleets make large catches.

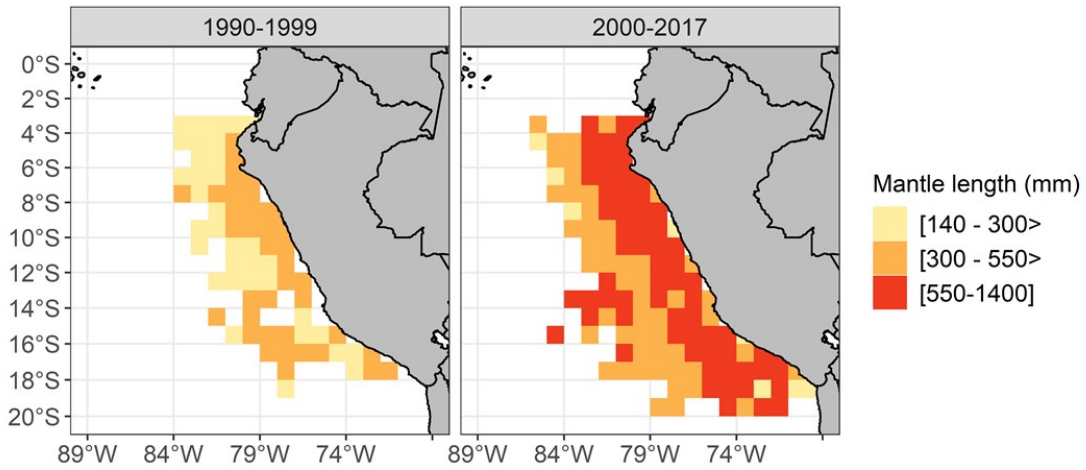

Figure 2. Spatio-temporal variation (decadal) of the phenotypic groups (determined by the range of sizes at maturity) of D. gigas in Peruvian waters and adjacent areas during the period 1990-2017

Recently Wang et al. (2023) mentioned that the spatiotemporal variation of the sizes on the coasts of Peru and Chile would lead to biases in the estimates of the spatiotemporal models, such as those assumed in the assessment carried out in Peru, given that according to Liu et al. (2015), there are likely different populations with different biological responses to environmental factors and climate change-induced environmental variability in these areas. It should be emphasized that Csirke et al. (2015) assumed a single stock in Peruvian waters considering that during the period analyzed (after 2000) one phenotypic group was predominant. But we agree with Wang et al. (2023), stating that, when considering broader spatiotemporal scales, covering several decades and high seas areas in the southeastern Pacific, there are surely different stocks, with different characteristics and responses to the variable conditions of the environment and marine ecosystem in the southeastern Pacific.

Regarding the probability of the existence of different populations with different biological responses to environmental factors and environmental variability (Liu et al. 2015), there is information that reports spatial (coast-ocean) and temporal (decades) variations of the size at maturity in Peruvian waters. Likewise, there is information on the high seas off Peru. Thus, Masuda et al. (1998) reported the dominance of mature specimens at sizes less than 40 cm in waters outside 200 nm off Peru, also mentioned that in areas north of 03°S during June-July all females were mature, even in the smallest size class (19 cm). Ye & Chen (2007) in the 2000s reported the predominance of specimens belonging to the medium size group in waters outside 200 nm off Peru, which would have longevities of less than one year of age considering smaller sizes at maturity. Liu et al. (2013, 2017 in Gong et al. 2018) mentioned that the predominant ages in the Central Eastern Pacific – CEP (area close to the northwest of the fishing area reported in Figure 1) were from 144 to 253 days old, and between 145-565 days old off the Peruvian Exclusive Economic Zone (PER), which represented between 70 and 90% of the squid caught in these two areas. In addition, differences have been found in the number of increments in the feathers of D. gigas collected in these two areas. The number of increments in the feathers of D. gigas from CEP was higher compared to the specimens collected in PER at the same age, attributing these differences to the different environmental conditions (Gong et al. 2018). (Fig. 3).

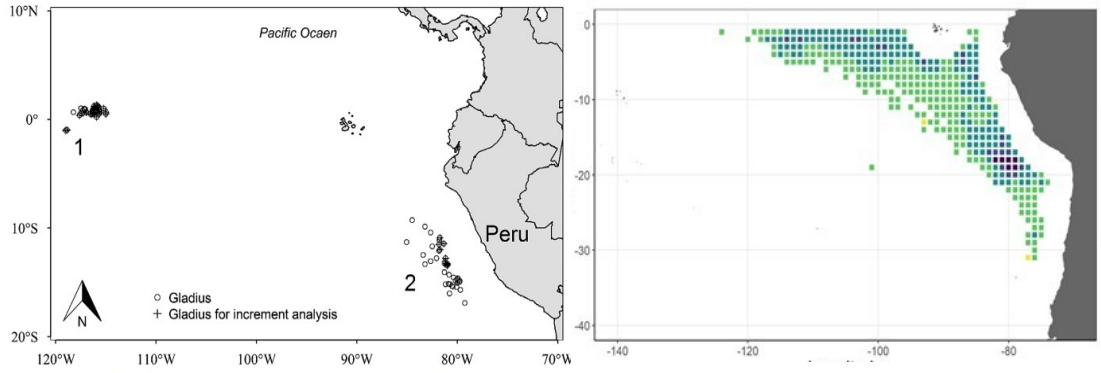

Figure 3. Left: Sampling sites. Dosidicus gigas collected in offshore waters of the Central Eastern Pacific (CEP, site 1) and off the Peruvian Exclusive Economic Zone (PER, site 2), taken from Gong et al. (2018), and Right: Total Jumbo flying squid catch (tons), across all years and fleets, aggregated to a 1° x 1° spatial resolution. SPRFMO, Secretariat May 6, 2022.

Knowing that there are phenotypic groups with different biological responses such as longevity, age at maturity, distribution, and also probably migrations (Csirke et al 2015), those characteristics should be considered for adequate identification of stocks or population units. Also, including the eventual presence of groups with different phenotypic characteristics, which behave as population subunits, is of great importance in the exercise of the assessment of fishing resources, as well as the calculation, formulation, and application of maximum catch limits and other measures of fishing management. Therefore, we agree that assessment exercises should be carried out considering various hypotheses about the population structure of D. gigas in the Southeast Pacific, since one single stock until two or three stocks must be tested, hypotheses that should consider biological characteristics.

Peru has been proposing that the spatial distribution of the phenotypic groups in the SPRFMO convention area be evaluated by determining the size at maturity. This information would make it possible to separate the phenotypic groups spatially. With this purpose, figure 4 shows the size structure of mature and spawning D. gigas females during the period 1989-2022. The sizes of mature and spawning individuals ranged between 13.7 and 128.0 cm in mantle length. Three groups could be identified, the first with a mean size of 34.62 mm (sd=4.88), the second with a mean size of 71.86 cm (sd=11.99), and the third with a mean size of 94.01 mm (sd=6.90). The first group would correspond to the group of specimens maturing to medium sizes (MM) that predominated in the 1990s, while the second and third groups would correspond to the group of specimens maturing to large sizes (LL) that predominated in the 2000s. The first group identified in Peruvian waters has a wider range of sizes than the one reported by Nigmatullin et al. (2001) and would include the group of early maturity (SS) This could be due to the scarce presence of small specimens found and that would not allow delimiting this group in Peruvian waters. Regarding groups 2 and 3 found in Peruvian waters, these correspond to the group of mature at large sizes, and due to the wide range of sizes, it has been possible to describe two groups, coinciding with what was found by Cordue et al. (2018) in Peruvian waters. The little overlap of sizes of the specimens from maturity to medium and large sizes found in Peruvian waters, allows a separation between these groups, finding a size of 47 cm that would separate these groups (Figure 5).

This exercise should be carried out in convention waters, so countries that fish in this area must make the greatest effort to collect biological information, as established by the CMM-02-2022 (Data standards).

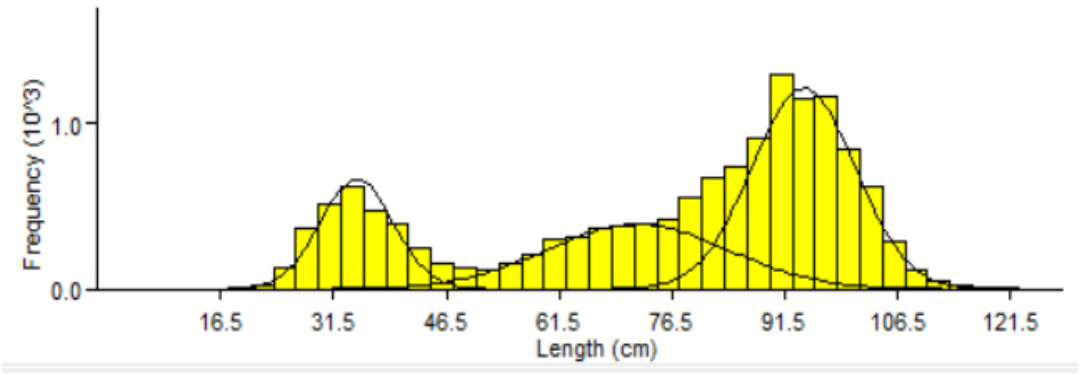

Figure 4. Structure by sizes of mature female specimens in Peruvian waters during 1989-2022

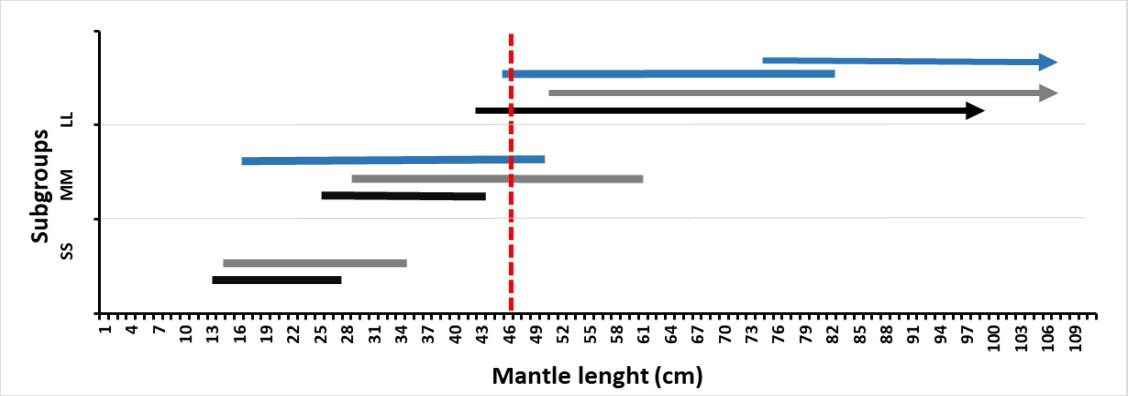

Figure 5. Size ranges of mature specimens (females: gray line, males: black line) by population subgroups (SS: small, MM: medium, LL: Large) reported by Nigmatullin et al. (2001), and those reported in Peruvian waters (females: blue lines). The vertical dashed red line indicates the size that would separate the medium and large maturity groups as found in Peruvian waters.

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