11th MEETING OF THE SCIENTIFIC COMMITTEE

11 to 16 September 2023, Panama City, Panama

SC11 – HM01
Abundance of jack mackerel and chub mackerel in the Peruvian sea between 2020 and 2023

Republic of Peru

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ABUNDANCE OF JACK MACKEREL AND CHUB MACKEREL IN THE PERUVIAN CURRENT IN THE HUMBOLDT SYSTEM BETWEEN 2020 AND 2023

by

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This report contains information on the Jack mackerel fish 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

In recent years there has been a positive trend regarding an increase of the jack mackerel abundance and availabilty, that is, an increase towards average levels of abundance in comparison with past decades. Catches in the same period (1983-2023) also show, in general, better fishing performance in years when calculated biomass has been higher. The calculated abundance of jack mackerel, using various stratification methods based on acoustic data collected during the summer 2023, have been given in a range of 53 to 223 thousand tons in the areas prospected by fishing vessels only.

Also, in recent years there has been a positive trend regarding the chub mackerel biomass, i.e. an increase towards average levels of abundance in comparison with past decades. Catches in the same period (1983-2023) show, in general, better catches in years when biomass has been higher. The calculated abundance of chub mackerel, using various stratification methods based on acoustic data collected during the summer 2023, have been given in a range of 100 to 750 thousand tons in the areas prospected by fishing vessels only.

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1. Introduction

The Scientific Research Committee (CIC) of the National Fisheries Society (SNP), in cooperation with the Humboldt Institute for Marine and Aquaculture Research (IHMA) organized the **Eleventh SNP Workshop on the habitat conditions of jack mackerel and other species of the Peruvian Current in the Humboldt System**, which was held virtually from 26 to 30th June 2023. It has counted, as usual, with the valuable participation and contribution of researchers from the Peruvian Sea Research Institute (IMARPE).

One of the topics discussed during the workshop was the need of resuming the analysis of acoustic data collected by fishing vessels during fishing trips with quantitative purposes to contribute to the understanding of the bio-ecology of resources such as jack mackerel and chub mackerel. Fishing trips are random, which introduces an additional uncertainty that is common to this type of survey, since that there is a risk of overestimating the fish biomass. Another source of uncertainty in random surveys is the fragmentation of the data, which may not be representative of the total area of distribution, so that is common a loss of continuity of the spatial data. To deal with those sources of bias, it has been applied several stratification methods in order to produce averaged values of acoustic density (NASC, m^2/n.mi.^{2}).

2. Description of the abundance of jack mackerel and chub mackerel using acoustic and geostatistical techniques

2.1. Estimation of the abundance of jack mackerel and chub mackerel

In the present case, *abundance* or observed biomass is understood as the quantity of fish (jack mackerel and chub mackerel) measured in units of mass (tonnes) only in the areas of operation of the fishing fleet. On the other hand, biomass is the total amount of fish in all its possible distribution area, which is expressed in units of mass, which cannot be measured only with fishing trips, since the fleet operates in limited areas. According to Peruvian regulations, the fleet cannot operate within the first 10 miles of coastline and neither in areas with the presence of juveniles.

Since the first workshop on jack and chub mackerel (2011), two methods have been used to estimate the abundance of these species. The first method is acoustic, i.e. a number of fishing vessels equipped with digital acoustic detection systems (echosounders) of 120 kHz frequency, have collected information to be analyzed during the annual workshops.

The second method used is geostatistical, through which all fishing sets made between 2020 and 2023, both for jack mackerel and chub mackerel, have been regionalized into 8 zones in order to weekly estimate the centers of gravity and inertia associated with each region. The information was also grouped into weeks (35 effective fishing weeks from January 2020 to March 2023). The average catch per fishing set and area/week was used as an indicator (proxy) of fish density (tonnes/mn^2). In this way, the multiplication of the average catch by the also calculated inertia yields an abundance in tons, which is assumed proportional to the biomass only in the areas of operation where the fleet has operated. The methodological details used for data analysis are described in SNP (2015).

2.1.1. Jack mackerel biomass estimated by IMARPE using acoustic methods

Information on latitudinal acoustic biomass and annual jack mackerel catches along the Peruvian coast has been updated. For this, information from IMARPE acoustic surveys has been used; the annual landing data has been collected from the website of the Ministry of Production. Figure 2.1.1.1 presents a Hovmoller diagram of changes in latitudinal jack mackerel biomass between 1983 and March 2023.

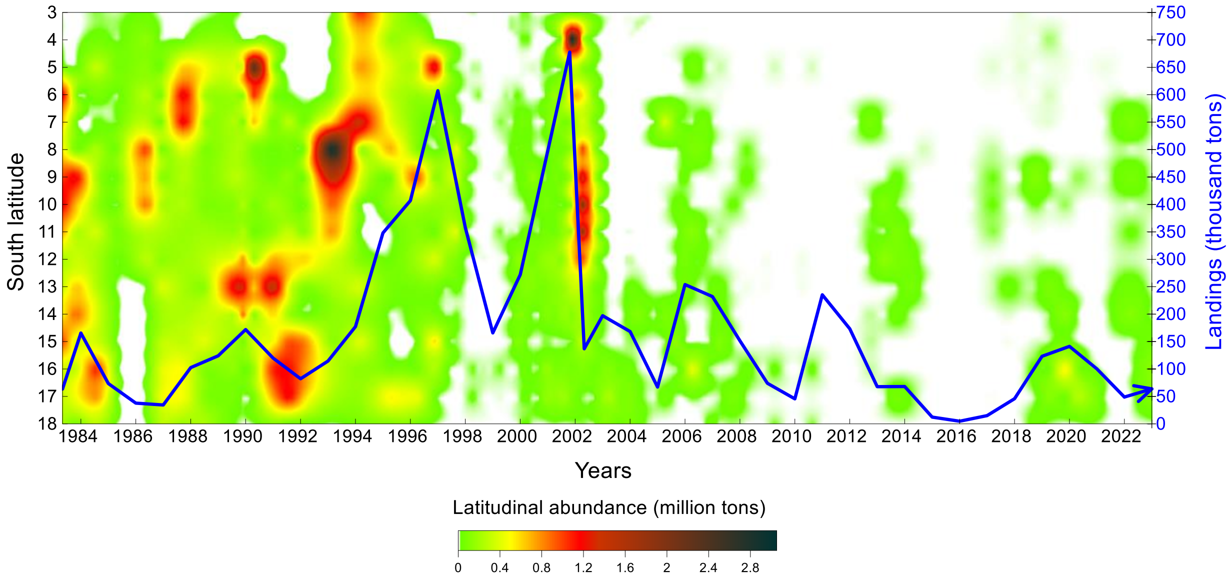

Figure 2.1.1.1. Hovmoeller diagram on latitudinal biomass of jack mackerel along the Peruvian coast, represented by the vertical axis on the left between 1983 and 2023 (horizontal axis). The captures are represented by the blue line and the right vertical axis. The colors correspond to biomasses according to the legend of the figure.

In general, two regimes are observed: one between 1983 and 2002, in which biomass fluctuated between medium and high levels; and another regime exists after 2002 with abundances varying between medium and low levels. However, in recent years there has been a positive trend in biomass, i.e., an increase towards medium levels of biomass. Catches in the same period (1983-2023) also show, in general, better yields in years when biomass has been higher.

2.1.2. Abundance of jack mackerel calculated by geostatistical methods

Figure 2.1.2.1. shows the location and distribution of the made fishing sets on jack mackerel during February and March 2023. The industrial fishing quota for jack mackerel, granted by PRODUCE for 2023, was completed by mid-March. The fishing sets have been classified by geographical areas along six weeks, in order to determine the average catch (tonnes/mn2), the Centre of Gravity (latitude, longitude) and inertia (mn2) in each of them.

Jack mackerel fishing hauls sets have been observed off the edge of the continental shelf, from 20 to 100 nautical miles from the coast, and between latitudes 11°30'S (Chancay) and 15°00'S (Punta Caballas). 643 fishing sets have been made, with catches ranging from 1 to 493 tonnes per set. The average catch was 91.54 tonnes per set. 58,771 tonnes of jack mackerel have been caught between February and March 2023.

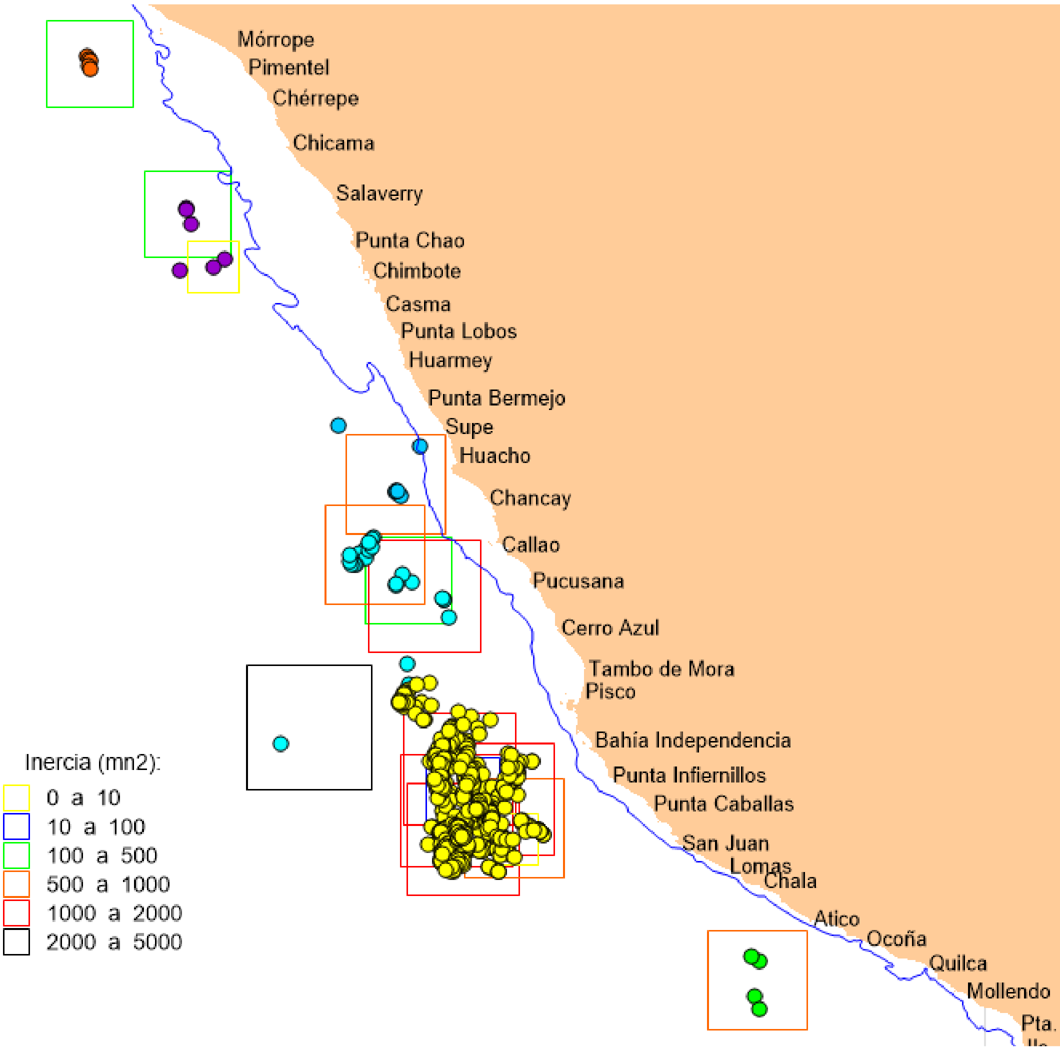

Figure 2.1.2.1. Distribution of jack mackerel fishing sets and related inertia between February and March 2023. The red circles correspond to the area of Chicama, the purple to Chimbote, and the blue sky to Supe. The blue to Callao, the yellow to Pisco and the green circles to the south. The centers of gravity and the magnitude of inertia (indicated by squares according to the legend in the figure) have been determined in each zone and week in order to estimate the abundance of jack mackerel using as a proxi the average catch per set, per region and per week.

In Figure 2.1.2.2. they are observed the estimated abundances (tonnes) and inertia (mn2) for the distribution of jack mackerel using geostatistical methods between January 2020 and March 2023. It should be pointed out that the lack of estimates for certain months is due to the fact that the fishing vessels were participating in the anchovy fishing seasons or because the corresponding fishing quota was reached. The highest abundance of jack mackerel was estimated during March 2020, with 855 thousand tons, followed by January 2020 with 518 thousand tons. The highest calculated inertia, which is an indicator of the jack mackerel distribution area only in areas where the fleet operated, was 9,914 mn2 during March 2020. The average value of the distribution area is 2,513 mn2.

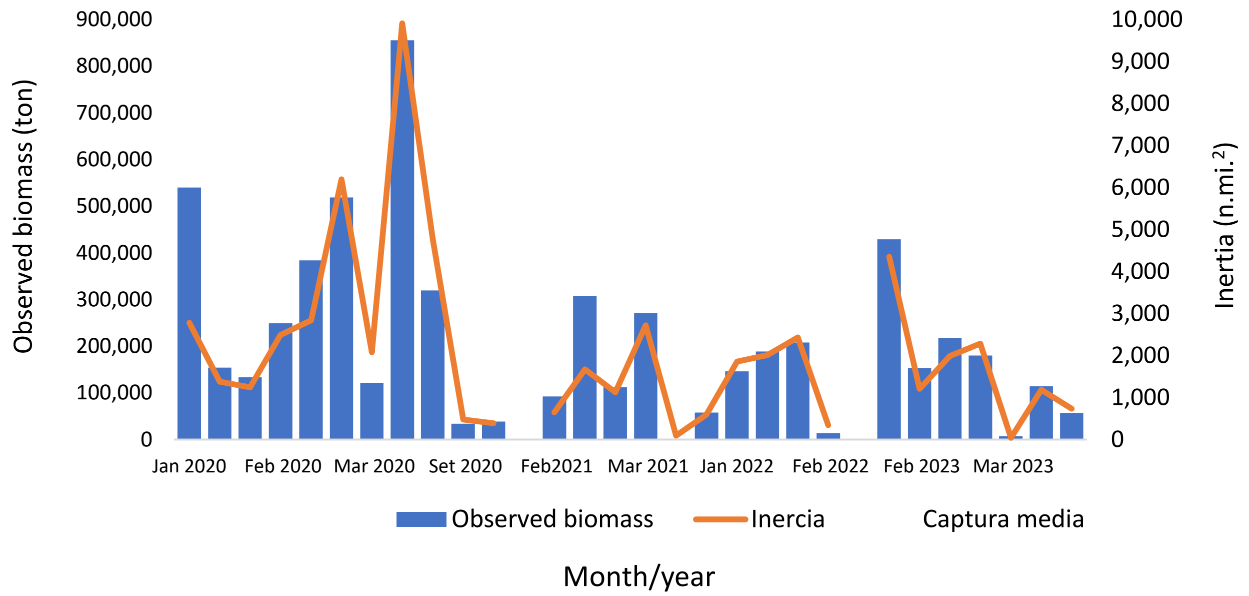

Figure 2.1.2.2. Observed biomass and inertia of jack mackerel between January 2020 and March 2023. The estimates shown in blue bars have been made by grouping by weeks the catch data per fishing sets.

2.1.3 **Geographical distribution of jack mackerel according to acoustic records obtained between 2020 and 2023**

The geographical distribution of jack mackerel from 2020 to 2023 was acoustically measured during scientific surveys and fishing seasons. The analysis of the data shows that jack mackerel is mainly located south of degree 12°S, with larger continuity of acoustic records between south degrees 13 and 17°S. Some isolated areas were detected near Paita, Punta Falsa, Chicama, Chimbote and Huacho. The distribution reaches up to 120 n.mi. from the coast, but in general it is located within 50 n.mi. Figure 2.1.3.1.

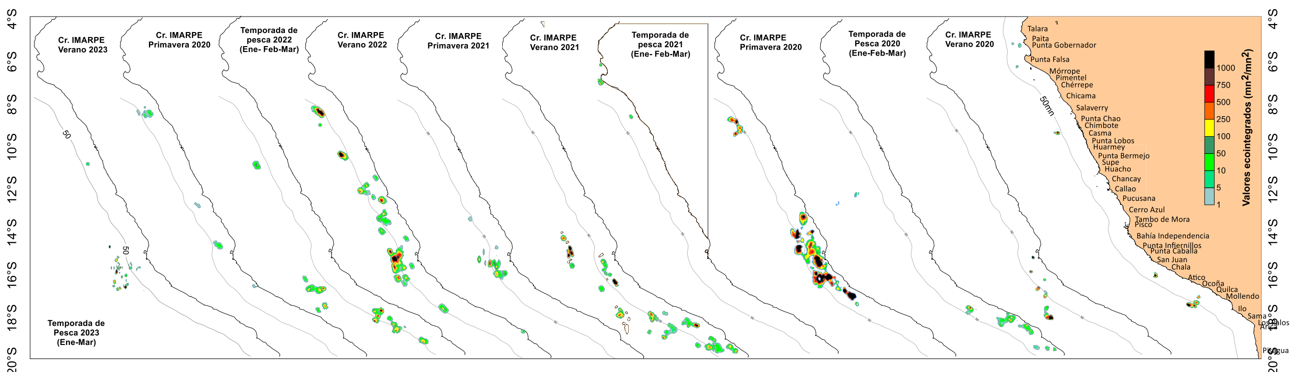

Figure 2.1.3.1. Geographical distribution of jack mackerel during IMARPE surveys and jack mackerel fishing seasons carried out between 2020 and 2023. Colors indicate acoustic density (NASC, $m^2/n.mi.^2$) according to ranges in the legend.

2.1.4 Vertical distribution of jack mackerel between 2020 and 2023.

The observed vertical distribution of jack mackerel shows that the fish was distributed until 86 meters depth, with an average value of 12.27 m. The shallowest schools were recorded between south degrees 4 and 12°S, while the deepest were recorded between 12 and 18°S. On the other hand, the densities were similar up to 40 m in day and night, then below 40 m during the day the densities were higher compared to the night.

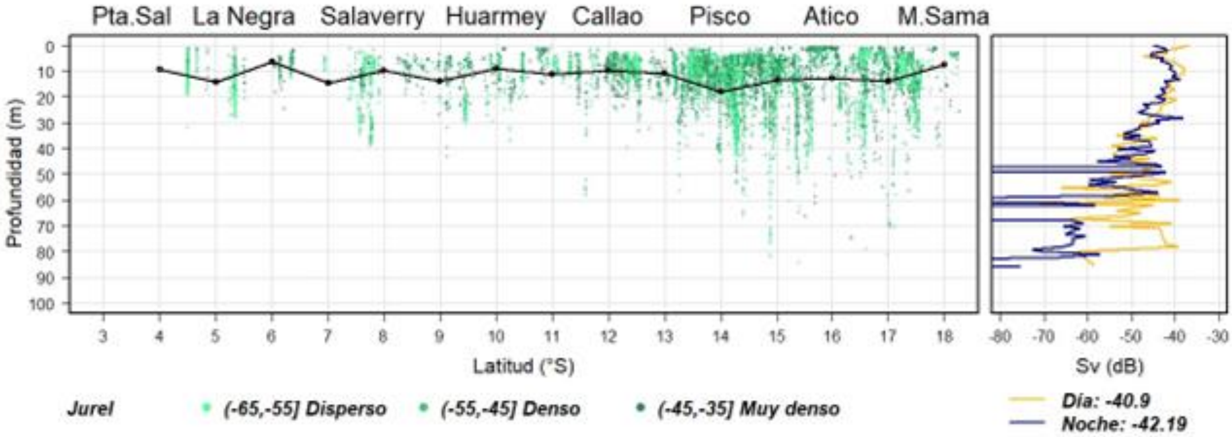

Figure 2.1.4.1. Latitudinal vertical distribution of jack mackerel from 2020-2023, during IMARPE surveys and fishing seasons carried out between 2020 and 2023. (x-axis: depth in meters); the right side panel shows the backscatter volume (Sv, dB re m^2/m^3) according to depth.

2.1.5. Chub mackerel biomass estimated by IMARPE using acoustic methods

Information on latitudinal acoustic biomass and annual chub mackerel catches along the Peruvian coast has been updated. For this, information from IMARPE acoustic surveys has been used; the annual landing data has been collected from the website of the Ministry of Production.

Figure 2.1.5.1. presents a Hovmoller diagram on changes in latitudinal chub mackerel biomass between 1983 and March 2023. In general, three regimes are observed: the first occurred between 1983 and 1992, in which the biomass presented a uniform distribution along the entire coast, although with average abundances; the second period was between 1992 and 2002, in which biomass fluctuated between medium and high levels; and a third regime exists after 2002 with abundances varying between medium and low levels.

However, in recent years there has been a positive trend in biomass, i.e. an increase towards medium levels of abundance. Catches in the same period (1983-2023) show, in general, better yields in years when biomass has been higher.

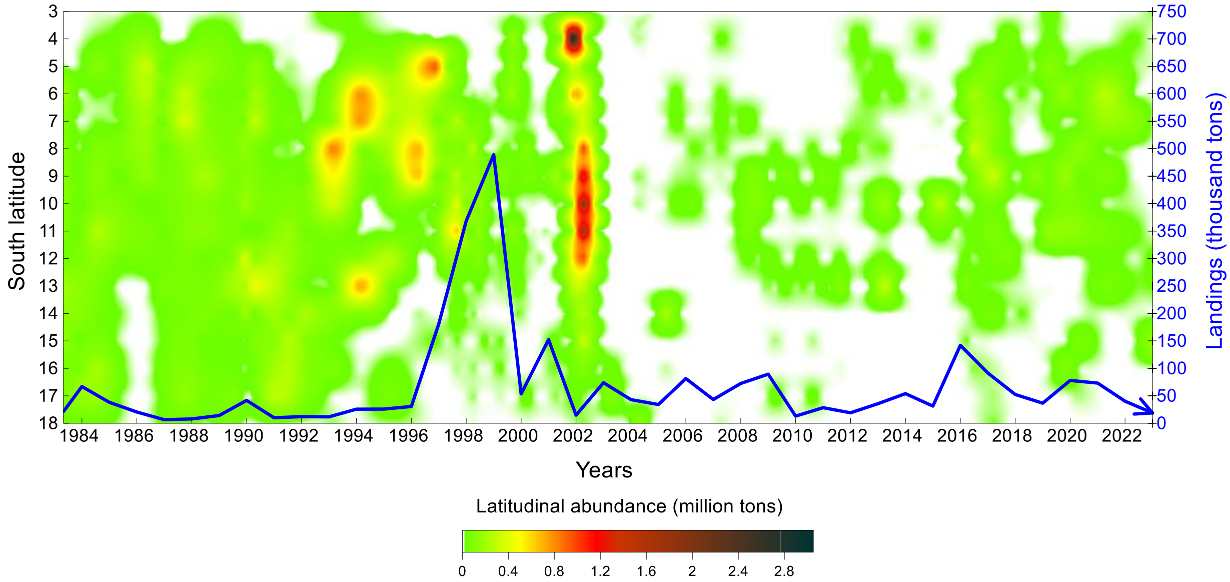

Figure 2.1.5.1. Hovmoeller diagram on latitudinal biomass of chub mackerel along the Peruvian coast, represented by the vertical axis on the left between 1983 and 2023 (horizontal axis). The captures are represented by the blue line and the right vertical axis. The colors correspond to biomasses according to the legend in the figure.

2.1.6. Chub mackerel abundance calculated by geostatistical methods

Figure 2.1.6.1. shows the location and distribution of fishing sets made on chub mackerel during February and March 2023. The fishing sets have been classified by geographical areas (8) and by weeks, in order to determine the average catch (tonnes/mn2), the Centre of Gravity (latitude, longitude) and inertia (mn2) in every one of them. Chub mackerel fishing sets have been observed off the continental shelf, from 10 to 200 miles from shore, and between south latitudes 9°00'S (Chimbote) and 15°00'S (Punta Caballas). 343 fishing sets have been made, with catches ranging from 1 to 350 tonnes per set. The average catch was 56.42 tonnes per set. 19,298 tonnes of chub mackerel have been caught between February and March 2023.

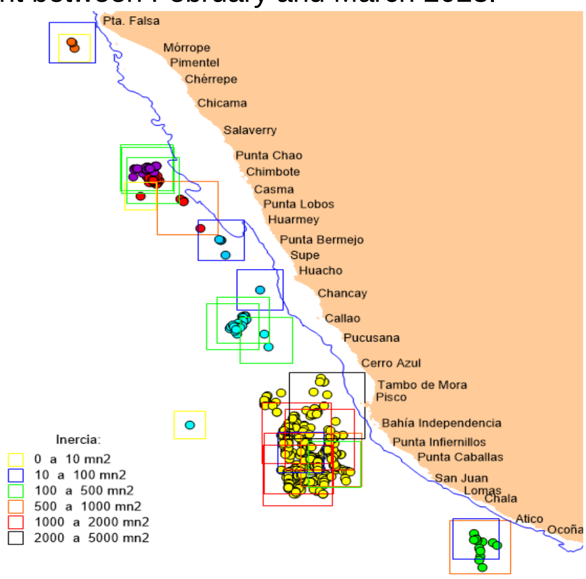

Figure 2.1.6.1. Distribution of chub mackerel fishing sets and related inertia between February and march 2023. The red circles correspond to the area of Chicama, the purple to Chimbote, the blue sky to Supe. The blue to Callao, the yellow to Pisco, and the green ones to the south. The centers of gravity and the inertia (indicated by squares according to the legend in the figure) have been determined in each zone and week in order to estimate the abundance of chub mackerel using as an indicator of observed biomass the average catch per set, per region and per week.

In Figure 2.1.6.2. they are observed the biomass (tonnes) and inertia (n.mi.^{2}) for chub mackerel by using geostatistical methods between January 2020 and April 2023. It should be noted that the lack of estimates in certain months is due to the fact that fishing vessels were participating in the anchovy fishing seasons, or due to the fact that fishing quota was caught. The highest abundance of chub mackerel was estimated during February 2020, with 247 thousand tons, followed by September 2020 with 236 thousand tons. The highest calculated inertia, which is an indicator of the chub mackerel distribution area -only in areas where the fleet operated- was 4,346 mn^2 during September 2020. The average value of the distribution area is 1,460 n.mi.^{2}.

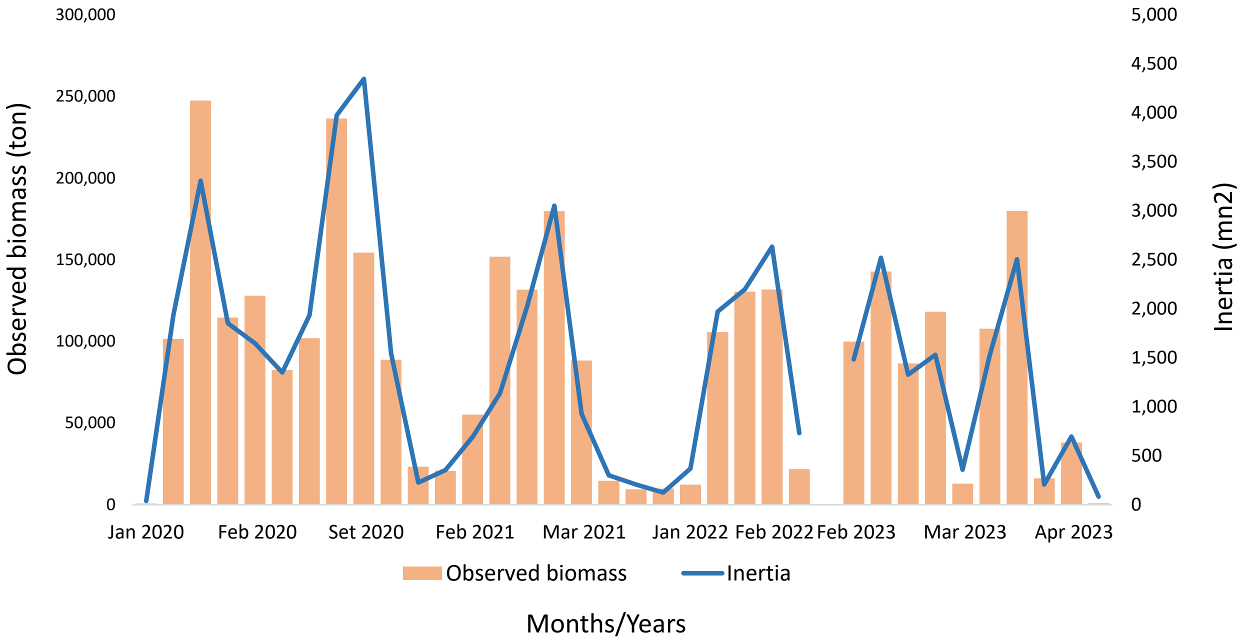

Figura 2.1.6.2. Observed biomass and inertia of chub mackerel during January 2020 and April 2023. The estimates shown in orange bars have been made by grouping the catches by weeks.

2.1.7. Estimation of the acoustic abundance of jack mackerel, chub mackerel and vinciguerria by using data collected aboard fishing vessels

In the present case, we used the data collected by the fishing vessels Jadranka B, Tasa 41 and Tasa 42; The acoustic data collected throughout the season were analyzed by weeks. In all cases, Simrad model ES70 echo sounders operating at the frequency of 120 kHz and split beam transducers were used. The basic sampling unit (UBM) was 1 n.mi., having sailed 9,183 n.mi. in total. Two methods have been applied for estimating the acoustic abundance; further details are presented below and in the annex of this document.

Fishing trips are random, not systematic, then a system of stratification of statistical squares in two dimensions or spaces of 15 by 15 mn (225 n.mi.^{2} of area) was adopted, in which all NASC measurements by UBM were averaged including zeros to avoid an overestimation in the results. The equation used for estimating biomass in each square Bi is:

$$Bi = NASC_i * \sigma_i^{-1} * A_i * Cos(lat_i) * w_{ij} * F_{ij}$$

$NASC_i$: Nautical Area Scattering Coefficient, in m^2/n.mi^2
σ^i: Scattering cross section, m^2
A_i: Area of every square, in n.mi.^{2}
Lat_i: Average of the latitude in every UBM
w_{ij}: Weigth, in tons
Fij: Relative frequency in every length class interval

An alternative estimate of biomass per quadrant consists of multiplying the average density by the area covered by the quadrants.:

$$Bi = \rho_i * A_{ij} * Cos(lat_i)$$

ρ_i : Fish density (tonns/n.mi.^{2})
A_i: Area of every square, in n.mi.^{2}
Lat_i: Average of the latitude in every UBM

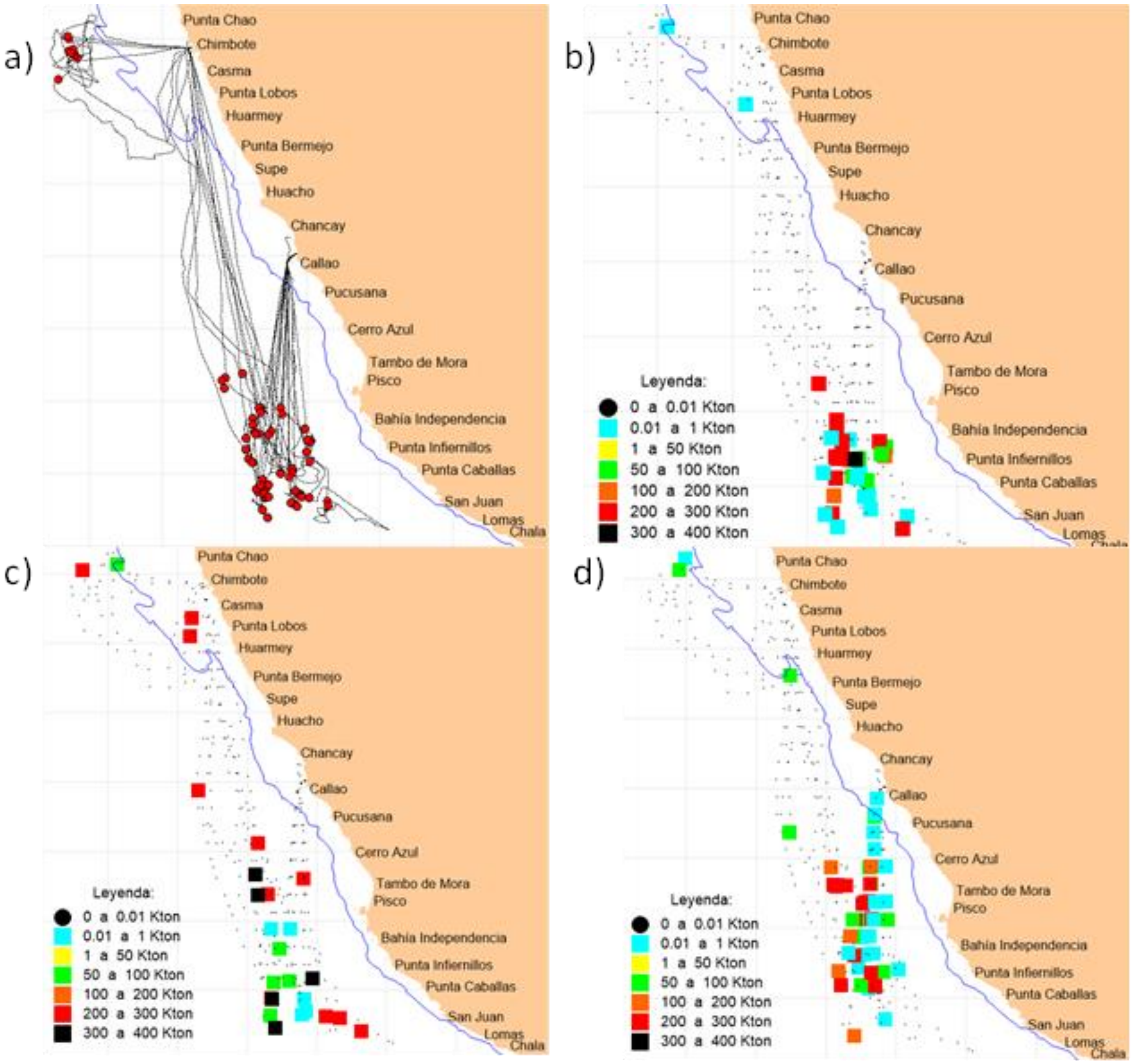

Figure 2.1.7.1. Acoustic assessment of the biomass of jack mackerel, chub mackerel and vinciguerria (*Vinciguerria lucetia*) calculated for statistical squares of 15 x 15 n.mi. in the area surveyed by three fishing vessels during February and March 2023. The top left panel (a) shows the overlapping routes of the fishing vessels; the red dots are places where fishing sets were made. The upper right panel (b) shows the statistical squares indicating the biomass of jack mackerel; The lower left panel represents the chub mackerel biomass (c). The lower right panel (d) shows the biomass of Vinciguerria.

2.2. Synthesis of measured biomass for jack mackerel (*Trachurus murphyi*)

It is presented in Figure 2.2.1. a synthesis of acoustic abundance measurements made for jack mackerel during February and March 2023. Jack mackerel biomass have been in a range of 8 to 223 thousand tons in the areas prospected by fishing vessels. Table 2.2.1 presents the main results, including the area covered each week by jack mackerel; Figure 2.2.2. shows the biomass of jack mackerel by sizes.

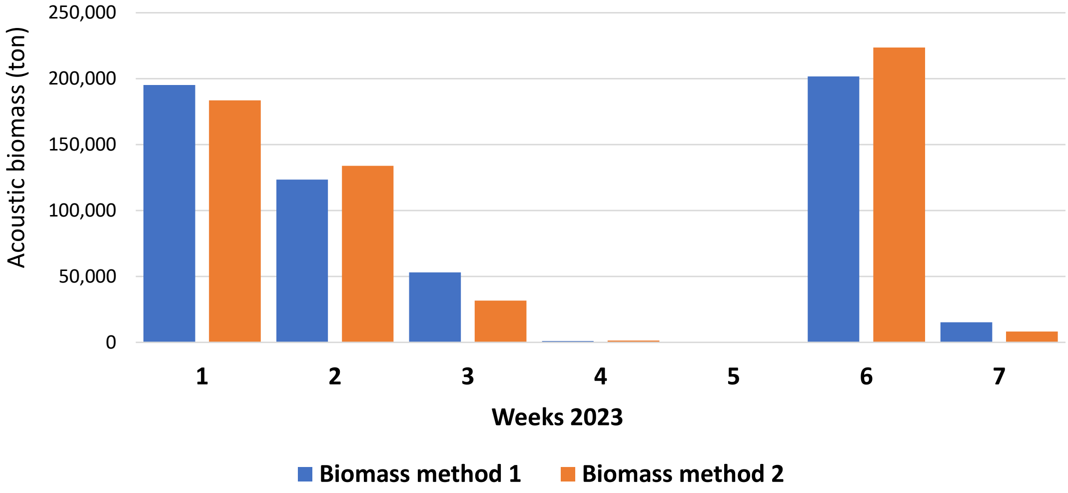

Figure 2.2.1. Synthesis of jack mackerel biomass estimates 2023 by weeks.

Table 2.2.1. Results of the acoustic biomass and estimates of statistical accuracy of the assessment made for jack mackerel

Results/Weeks	1	2	3	4	5	6	7	Units
Number of squares	7.00	9.00	2.00	3.00		10.00	2.00	squares
Area	1,524.43	1,956.10	435.61	656.54		2,181.73	433.66	n.mi.2
NASC:	1,162.62	716.43	337.11	7.00		1,288.68	104.44	m2/n.mi.2
Mean NASC	166.09	79.60	168.56	2.33		128.87	52.22	m2/n.mi.2
Standar deviation	179.40	84.43	238.38	2.86		135.84	73.85	m2/n.mi.2
Number of UBM	343.00	425.00	14.00	101.00		485.00	110.00	unidades
Weigthed mean NASC	160.44	89.16	96.75	2.86		134.86	28.01	m2/n.mi.2
Weighted variance	16,289.65	1,030.68	18,709.08	2.24		3,996.27	1,582.11	unidades
Conversion factor	0.75	0.77	0.75	0.74		0.76	0.68	ton/m2
Mean density	120.49	68.47	72.65	2.12		102.52	18.93	ton/n.mi.2
Variance of density	9,186.52	607.76	10,550.95	1.23		2,309.63	722.43	unidades
Coefficient of variation	79.55	36.01	141.38	52.28		46.88	142.01	%
Biomass method 1	195,179.26	123,463.22	53,043.91	1,053.33		201,667.56	15,226.95	ton
Biomass method 2	183,676.04	133,931.78	31,648.48	1,390.08		223,673.18	8,207.55	ton
Difference	5.89	-8.48	40.34	-31.97		-10.91	46.10	%
Confidence limitis	0.28	1.66	30.61	0.01		0.26	0.14	%
Mean size	44	45	41	39		40	37.00	cm
Range of size	29 a 60	31 - 58	29 - 59	31 - 55		31 - 55	37 - 38	cm

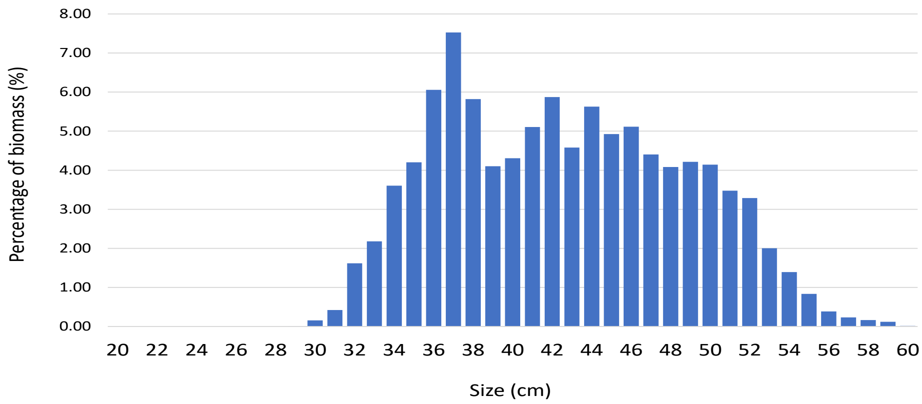

Figure 4.2.2. Weighted biomass structure for jack mackerel by sizes during February and March 2023

2.3. Synthesis of abundance measurement results for chub mackerel (*Scomber japonicus*)

Based on the results shown in Figure 2.1.4., they are presented in Figure 2.3.1. a synthesis of the acoustic biomass measurements made for chub mackerel during February and March 2023. Biomass of chub mackerel have been in a range of 36 to 751 thousand tons only in areas surveyed by fishing vessels. Table 2.3.1 presents the main results, including the area covered every week by chub mackerel. Figure 2.3.2. shows the acoustic biomass of chub mackerel by size intervals.

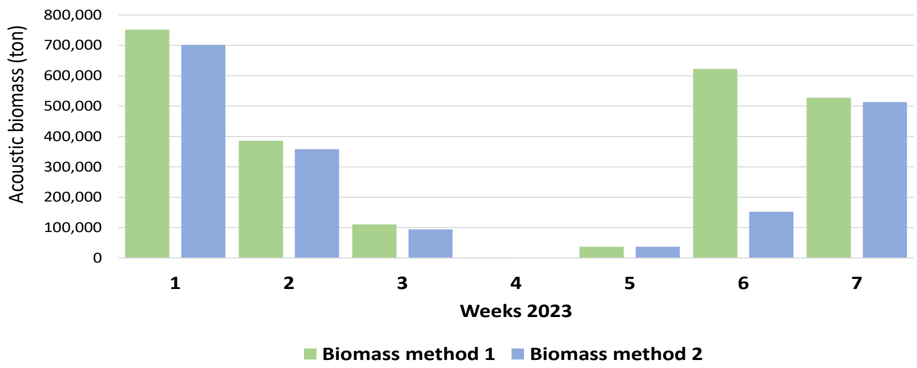

Figure 2.3.1. Synthesis of chub mackerel acoustic biomass by weeks.

Table 4.3.1. Results of the acoustic biomass and estimates of statistical accuracy of the assessment made for chub mackerel.

Results/Weeks	**1**	**2**	**3**	**4**	**5**	**6**	**7**	Units
Number of squares	4.00	5.00	2.00	3.00	2.00	6.00	6.00	squares
Area	872.49	1,085.32	437.20	656.54	444.09	1,312.39	1,305.90	n.mi.2
NASC:	5,553.16	2,855.17	818.35	16.00	274.49	4,688.84	3,891.05	m2/n.mi.2
Mean NASC	1,388.29	571.03	409.17	5.33	137.25	781.47	648.51	m2/n.mi.2
Standar deviation	1,603.06	505.34	578.66	6.53	194.10	856.06	710.40	m2/n.mi.2
Number of UBM	225.00	282.00	51.00	101.00	76.00	224.00	245.00	unidades
Weigthed mean NASC	1,269.89	533.47	344.23	4.09	135.14	187.30	629.43	m2/n.mi.2
Weighted variance	1,175,824.37	133,782.72	56,750.70	12.68	4.88	9,766.34	29,064.90	unidades
Conversion factor	0.63	0.62	0.62	0.57	0.62	0.62	0.62	ton/m2
Mean density	804.05	330.20	215.03	2.35	83.27	115.98	393.24	ton/n.mi.2
Variance of density	471,381.97	51,256.11	22,145.43	4.18	1.85	3,744.53	11,344.67	unidades
Coefficient of variation	85.39	68.56	69.21	87.09	1.63	52.76	27.09	%
Biomass method 1	751,553.77	386,339.39	110,633.90	2,185.00	37,070.27	622,145.28	527,499.34	ton
Biomass method 2	701,522.34	358,376.50	94,012.17	1,541.80	36,981.59	152,206.96	513,537.83	ton
Difference	6.66	7.24	15.02	29.44	0.24	75.54	2.65	%
Confidence limitis	0.95	2.11	0.87	0.04	0.00	621.32	0.29	%
Mean size	34.00	34.00	34.00	34.00	33.00	33.00	34.00	cm
Range of size	31 - 40	21 - 41	30 - 39	23 - 38	31 - 37	29 - 38	32 - 37	cm

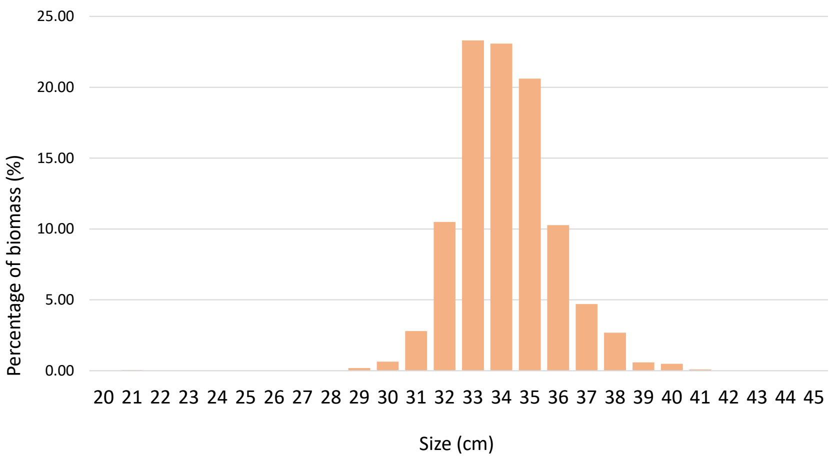

Figure 2.3.2. Acoustic biomass weighted by size intervals for chub mackerel during February and March 2023

2.4. Synthesis of acoustic biomass measurement made for Vinciguerria (*Vinciguerria lucetia*)

Based on the results shown in Figure 2.1.4.1 it is presented in Figure 2.4.1. a synthesis of the acoustic biomass measurements made for Vinciguerria during February and March 2023. Estimates of vinciguerria have been in a range of 4,400 to 2,437,000 tons in the areas surveyed by fishing vessels. Table 2.4.1 shows the main results, including the area covered each week by vinciguerria. To estimate the biomass of vinciguerria, an average size of 5 cm has been assumed, since there has been no biological sampling on this species.

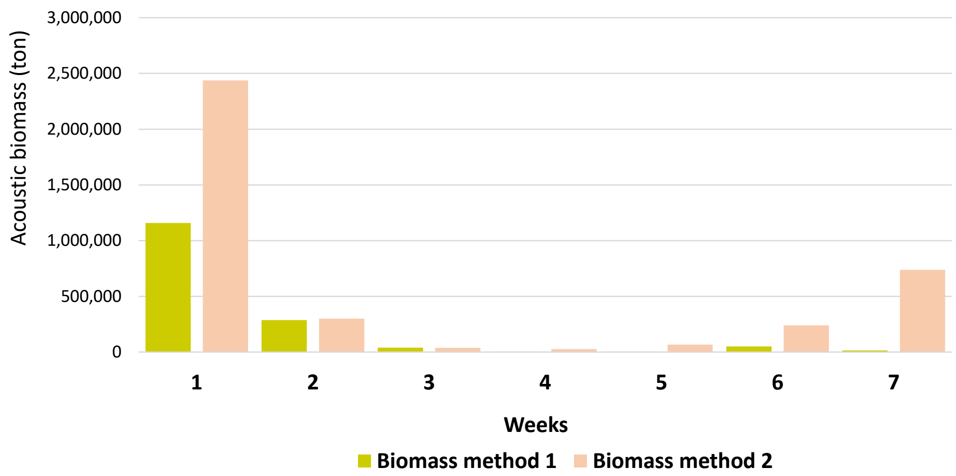

Figure2.4.1. Synthesis of the biomass of vinciguerria according to the used assessment methods.

Table 2.4.1. Results of acoustic biomass and estimates of statistical accuracy in the assessment made for vinciguerria

Results/Weeks	1	2	3	4	5	6	7	Units
Number of squares	13.00	14.00	7.00	3.00	2.00	15.00	2.00	squares
Area	20,191.29	3,063.49	1,531.21	7,032.29	9,540.49	19,107.93	10,929.42	n.mi.2
NASC:	1,121.08	556.80	77.68	6.78	4.24	100.78	28.65	m2/n.mi.2
Mean NASC	86.24	39.77	11.10	2.26	2.12	6.72	14.33	m2/n.mi.2
Standar deviation	0.00	62.21	17.37	4.70	1.41	14.81	28.65	m2/n.mi.2
Number of UBM	492.00	678.00	91.00	62.00	44.00	549.00	12.00	unidades
Weigthed mean NASC	51.20	41.52	10.42	1.71	2.98	5.35	28.65	m2/n.mi.2
Weighted variance	1,240.95	351.20	41.63	3.89	16.49	9.19	1,641.72	unidades
Conversion factor	2.36	2.36	2.36	2.36	2.36	2.36	2.36	ton/m2
Mean density	120.72	97.88	24.57	4.03	7.03	12.61	67.54	ton/n.mi.2
Variance of density	6,897.13	1,951.96	231.40	21.64	91.67	51.07	9,124.59	unidades
Coefficient of variation	68.80	45.14	61.91	115.35	136.14	56.66	141.42	%
Biomass method 1	1,158,110.41	287,033.69	39,986.81	3,480.00	4,441.94	51,946.43	14,768.21	ton
Biomass method 2	2,437,397.30	299,842.03	37,621.74	28,358.90	67,095.36	241,010.13	738,225.13	ton
Difference	-110.46	-4.46	5.91	-714.91	-1,410.50	-363.96	-4,898.74	%
Confidence limitis	2.58	0.07	0.18	0.06	0.11	0.04	0.00	%

3. Conclusions

- For jack mackerel biomass, two regimes are observed between 1983 and March 2022: one between 1983 and 2002, in which the biomass fluctuated between medium and high levels; and another regime exists after 2002 with abundances varying between medium and low levels. However, in recent years there has been a positive trend in jack mackerel biomass, i.e. an increase towards average levels of abundance. Catches in the same period (1983-2023) also show, in general, better yields in years when biomass has been higher.

- The geographical distribution of adult jack mackerel is located mainly south of Callao. Vertically, the schools of jack mackerel on average are located in 12 meters depth, but south of degree 13°S fish schools are deeper.

- For chub mackerel biomass, three regimes are observed between 1983 and March 2023: one between 1983 and 1992 in which a uniform distribution was observed along the entire coast, although with average abundances; the second period occurred between 1992 and 2002, in which biomass fluctuated between medium and high levels; and a third regime exists after 2002 with abundances varying between average and low abundance levels. However, in recent years there has been a positive trend in chub mackerel biomass, i.e. an increase towards medium levels of abundance. Catches in the same period (1983-2023) show, in general, better yields in years when biomass has been higher.

- Geographically, the observed distribution of chub mackerel is wider than the one of jack mackerel. Also, as usual, during the summer 2023 an overlap was observed in the distribution of jack mackerel and chub mackerel.

- During summer 2023, the presence of jack mackerel eggs and larvae has been recorded again in fishing areas, mainly in the southern Peru.

4. Bibliography

SNP (2015). VI SNP Diagnostic Workshop on the Resource Jack mackerel (*Trachurus murphyi*). Acoustic, geostatistical and biometric analysis protocols used in the diagnosis of the population condition of jack mackerel. Scientific Research Committee (CIC) of the National Fisheries Society (SNP). Lima, 109 pp.

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Annex: Summary of acoustic assessment methods used for jack mackerel and chub mackerel biomass calculation during summer 2023

The sub-Group of Specialists on acoustic assessment methods (SGAM) of the Habitat Monitoring Working Group (HMWG) agreed to share acoustic RAW data to perform and test different methods and stratification approaches to produce fish abundance analysis.

The present annex contains the main results obtained through acoustic analysis performed by using Echoview software. The exported logbooks were processed using Surfer software to obtain variograms and mapping of results. Fish abundance calculations were made by using Excel templates.

Acoustic RAW data

All data was collected using Simrad ES70 sounders operating at a single frequency (120 Khz) Split beam; echo sounders were calibrated following ICES standards.

CSV files were created by exporting them from Echoview V12.1; there were exported data files from cells, regions and regions by cells by species.

Just for the evaluation of different assessment methods on Chilean Jack Mackerel (CJM) it was agreed to assume this data as "unbiased" due to fish migration, fish avoidance, fish distributed in blind areas, wrong identification etc.

It was used a stratification of 1 n.mi. of Elementary Sampling Distance Units (ESDUs) containing NASC values for CJM (though including zeroes), in square areas of 15 by 15 minutes of latitude and longitude (so that in a complete degree of latitude/longitude there are 4 x 4 squares).

Then it was calculated the mean NASC (m2/n.mi.2) for CJM in every square for every one of the weeks during the 2023 summer fishing season.

Coding of areas

Every raw in the "cells" and "regions by cells" datasets were coded as follows:

Latitude: -11.213456   Longitude: -77.368712
Code: 1120   +   7725   = 11207725

This way of coding areas use the round data to two decimals, so that the created areas are necessarily 1/4 of latitudinal or longitudinal degree. Then, in every Marsden square there are 4 by 4 smaller squares.

Used equations

TS = 20 * log L – 66; dB (Peña 2008)
$\sigma = 4 * \pi * 10^{TS/10}$; m^2
$Wi = a * L^b/1'000,000$ Ton ; L: fish size (cm); a and b from literature
a = 0.02341
b = 2.94

Bi : Biomass per square (ton)
$Bi = NASC_i * \sigma i_j^{-1} * w_{ij} * A_i * \cos(Lat_i) * P_{ij}$
B: Total biomass
B = Σ Bi

A_i : Area of every square i" (n.mi.2) , 15 x 15 = 225 n.mi.
Lat_i: mean Latitude of every square i

P_{ij}: corresponding fraction per square i and j fish size interval

The available data also include fish length data by sets.