SPRFMO
South Pacific Regional Fisheries Management Organisation

8th MEETING OF THE SCIENTIFIC COMMITTEE

New Zealand, 3 to 8 October 2020

SC8-HM03

Jack and Chub Mackerel 2011-2020

Peru

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NATIONAL FISHERIES SOCIETY – SNP
HUMBOLDT INSTITUTE OF MARINE AND AQUATIC RESEARCH - IHMA

South Pacific Regional Fisheries Management Organization
8th Meeting of the Scientific Committee
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SYNTHESIS ON THE OBSERVED CHANGES IN THE DISTRIBUTION AND ABUNDANCE OF JACK MACKEREL (*Trachurus murphyi*) AND CHUB MACKEREL (*Scomber japonicus*) IN THE PERUVIAN CURRENT BETWEEN 2011 AND 2020

SCIENTIFIC RESEARCH COMMETEE - SNP

This report contains information on the Jack mackerel fish stock and fishery in Peruvian jurisdictional waters that, we reiterate, the delegation of Peru provides voluntarily and in use of its discretionary powers for the purposes of information and scientific research within the Scientific Committee of the SPRFMO. In doing so, it is also reiterated that Peru has not given the express consent contemplated in Article 20 (4) (a) (iii) of the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean. Therefore, as established in Article 5 of the Convention, it is reaffirmed that the decisions and conservation and management measures adopted by the SPRFMO Commission are not applicable to the jurisdictional waters of Peru.

LIMA, PERU, SEPTEMBER 2020

SOCIEDAD NACIONAL DE PESQUERÍA
INSTITUTO HUMBOLDT DE INVESTIGACIÓN MARINA Y ACUICOLA

SYNTHESIS ON THE OBSERVED CHANGES IN THE DISTRIBUTION AND ABUNDANCE OF JACK MACKEREL (*Trachurus murphyi*) AND CHUB MACKEREL (*Scomber japonicus*) IN THE PERUVIAN CURRENT BETWEEN 2011 AND 2020

SCIENTIFIC RESEARCH COMMITEE - SNP
SEPTEMBER 2020

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Summary

Since 2011, the National Fisheries Society (SNP) has carried out annual workshops for the diagnosis of jack mackerel and other species in order to contribute to fisheries and ecological research on these species. This research is carried out in coordination at the local (national) and regional levels by IMARPE and SPRFMO.

During a decade it has been compiled a series of information obtained during fishing seasons of the Peruvian industrial. That data is being used by the scientific community to deepen the study of the habitat of jack mackerel and chub mackerel in order to contribute to its sustainable exploitation.

This document contains a synthesis of the environmental conditions observed in the Peruvian current from 2011 to 2020, in order to relate the variability of oceanic conditions to the availability of jack mackerel and chub mackerel. The used fishery and acoustic data is only related to the Peruvian jurisdiction in the northern region of the Humboldt Current System. Accordingly, they are summarized here the main results on the distribution and abundance of both species, including measurements on the size structure during the last decade.

Table 1 presents a summary of the main oceanographic and distribution parameters and abundance of jack mackerel and chub mackerel between 2011 and 2020. Regarding catches, the data included is only related to the fleet of the fishing companies associated to SNP. The abundance calculations are only related to areas where the fishing fleet operated.

Table 1. Synthesis of catches and abundance of jack mackerel and chub mackerel, as well as environmental conditions observed between 2011 and 2020.

Parameters/Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Condition of sea surface temperature (°C)	Cold	Normal-warm	Cold	Normal	Warm	Warm	Warm	Cold	Normal	Normal
El Niño	-	-	-	-	Moderate	Weak	Moderate	-	-	-
La Niña	Moderate	-	-	-	-	Moderate	Moderate	Weak	-	-
Reported fishing sets	2971	1944	1207	1675	-	-	-	733	861	1401
Trend of distribution jack mackerel	North	Central-south	Central-south	Central-south	Central-south	Central-south	Central-south	North-central	Central-south	Central-south
Jack mackerel catches	208000	113000	28000	45000	20000	13500	10505	37106	86981	76000
Geoestat. Jack mackerel abundance (ton)	639000	158000	70000	163000	-	-	-	91166	511813	396109
Acoustic jack mackerel abundance (ton)	788764	476947	87000	332000	-	-	-	-	250000	200000
Modes jack mackerel (cm)	32	33	33 and 43	33	25	24	24 and 29	28	26 and 34	38
Size range jack mackerel	26-34	27-36	23-48	24-43	22-28	24-26	15-46	21-46	28-45	26-52
Chub mackerel catches (ton)	42000	7000	30000	28000	35000	140000	89428	30821	39916	48556
Geoestat. chub mackerel abundance (ton)	86140	9787	-	219746	15211	864359	782514	23254	403858	341519
Modes chub mackerel (cm)	29	31	32	32	29	27	29	26	15 and 33	28
Size range chub mackerel	28-30	25-37	20-36	24-40	24-37	20-34	20-36	22-37	27-40	25-38

1. Introduction

The Southeast Pacific is subject to a high environmental variability that influence on the habitat and population dynamics of all marine populations at different trophic levels. Variability can be short-term (seasonal), mid-term (inter-annual), long-term (decadal), and very long-term (secular) (Espino 2003[1], Espino & Yamashiro 2012[2]). Fishery resources are then affected by changes in oceanic conditions, especially in coastal areas of the Peruvian Current, which covers the northern region of the Humboldt Current System. In the specific case of the Peruvian combined fishery of jack mackerel and chub mackerel the effect of environmental variability is expressed through changes in their availability and accessibility over time.

Jack Mackerel (*Trachurus murphyi*) is a transzonal species, whose distribution includes the subtropical waters of the South Pacific Ocean, from South America to New Zealand and Australia. Its fishery is one of the most important of the region. Jack mackerel has been exploited since the 1970s, with annual catches ranging from less than 0.5 to almost 5 million tons. Since 2013 the South Pacific Regional Fisheries Management Organization (SPRFMO) it being managing its sustainable exploitation in the convention area.

Chub mackerel (*Scomber japonicas*) is also a transzonal species. Its distribution is mainly related to the transition zone between coastal, equatorial and subtropical waters along the south Pacific, hence its distribution is also wide and overlapped with jack mackerel.

In the marine Peruvian jurisdiction, the combined fishery of jack and chub mackerel yields the third place of national catches after anchovy (*Engraulis ringens*) and giant squid (*Dosidicus gigas*), with volumes ranging from 55,000 to 250,000 tons between 2011 and 2020.It must be noticed that these catches are not official numbers and correspond to the fishing fleet of companies associated to SNP.

Due to importance of that fishery, the Scientific Research Committee (SRC) of the National Fisheries Society (SNP), in cooperation with academic entities, has carried since 2011 an annual diagnosis on the habitat and main population conditions of jack mackerel and chub mackerel, based on information collected by the fleet. That initiative complements the research carried out at a national level by IMARPE and universities, to also contribute to the management of the fishery made by the Ministry of Production (PRODUCE).

It is considered essential to monitor the changes of the habitat of those species, also to deepen into the knowledge about the ecology of the species under study. Therefore this report summarizes the main results of the habitat workshops carried out by SNP since 2011, and seeks to generate a contribution to the Habitat Monitoring Working Group (HMWG) in the framework of the eighth meeting of the Scientific Committee of the Regional Fisheries Management Organization for the South Pacific (SPRFMO) that will take place during October 2020.

[1] Espino M. (2003). Estrategia de gestión oriental para el Pacífico Oriental con especial mención a la pesquería peruana. Tesis. Facultad de Ingeniería Geológica, Minera, Metalúrgica y Geográfica. Universidad Nacional Mayor de San Marcos, Lima. 102 pp.

[2] Espino M. & C. Yamashiro. (2012). La variabilidad climática y las pesquerías en el Pacífico Sudoriental. Latin American Journal of Aquatic Research 40(3): 705 – 721. DOI: 103856/vol40 – issue3 – fulltext – 18.

1.1. On the difference between the concepts of biomass and abundance

This report refers to “acoustic abundance” and “geostatistical abundance”. These expressions are related to the quantity of fish that has been calculated only in the areas of operation of the fleet. It is necessary to emphasize that these definitions do not refer to the total biomass of fish in the Peruvian Current, since the operations of the fleet only cover a variable fraction of the probable total distribution area of jack mackerel and chuck mackerel. Likewise, it is pertinent to bear in mind that the Peruvian jack mackerel fleet also has authorization to fish chub mackerel, and that it generally operates only during the summer and early autumn, since the same fleet also has an anchovy fishing permit. In other words, that one of jack and chub mackerel are a combined fishery.

The two anchovy fishing seasons usually extend between April and August, and from November to January. That is why in few years there are catches o jack and/or chub mackerel in months different than January to April.

2. Objectives

The objectives of this report are:

- Describe the environmental changes that occurred between 2011 and 2020, with an emphasis on summer seasons.
- Describe the changes in the availability of jack mackerel and chub mackerel during the last decade as a function of environmental variability.
- Describe the modal progression of jack mackerel and chub mackerel during the studied period.
- Present a synthesis of the results on the abundance calculations of both species between 2011 and 2020 in the areas of operation of the fleet.

3. The habitat of jack mackerel and chub mackerel using satellite oceanographic and fishery information sources between 2011 and 2020

3.1. Sea Surface Temperature (SST, °C)

In Figure 3.1.1. mean sea surface temperature (SST, °C) is presented for February between 2011 to 2020 as a proxy of the summer conditions in every year, indicating the fishing sets made for jack mackerel and chub mackerel (indicated by color symbols). The objective is to appreciate the thermal changes that occurred in the last decade and its possible relationship with the distribution, abundance and availability of jack mackerel and chub mackerel.

SST during February 2011 presented cold to normal conditions along the coast with temperatures between 17°C and 24°C, unlike in 2012, which registered warmer temperatures mainly in the southern zone. For 2013 the thermal conditions varied between 17°C and 21°C. In 2014, a larger thermal contrast was observed between the coastal zone and the oceanic zone (18°C-26°C).

In 2015 there were temperatures slightly above average, and for February 2016 the SST values were higher in the northern zone due to the occurrence of an El Niño event of weak intensity. In the summers of 2016 and 2017, other El Niño-like events took place, with very low catches of jack mackerel. Instead there were significant catches of chub mackerel.

The availability of jack mackerel and chub mackerel has been observed along the thermal fronts during summers 2018 and 2019 when a normal range of temperatures was observed. During those summers the fishing sets were made west of the limit of continental shelf (200 m depth isoline). Finally, during summer 2020 the distribution of jack mackerel and chub mackerel was atypical for the season, that is, the catches were made in areas with relatively high temperature and positive thermal anomalies, not along the fronts as usual.

In general, the thermal conditions between 2011 to 2014, and from 2018 to 2020 have led to a higher availability of jack mackerel, especially in the southern area, except for 2011, when jack mackerel was caught along the entire coastline. In contrast, years 2015 to 2017 were warm years in which El Niño-like events developed. Those conditions are not favorable for the concentration of jack mackerel. Chub mackerel, instead, has been distributed in those years with a tendency towards the north, since its habitat is more related to warm conditions (equatorial waters); accordingly, the chub mackerel availability was higher between 2015 and 2017. Likewise, it has been observed that chub mackerel can distribute over the continental shelf, which is not the case for jack mackerel, whose preference are the thermal fronts and mixed waters between subtropical surface waters (SSW) and cold coastal waters (CCW) with the only exception of summer 2020 when jack mackerel was available to fishing in SSW exclusively.

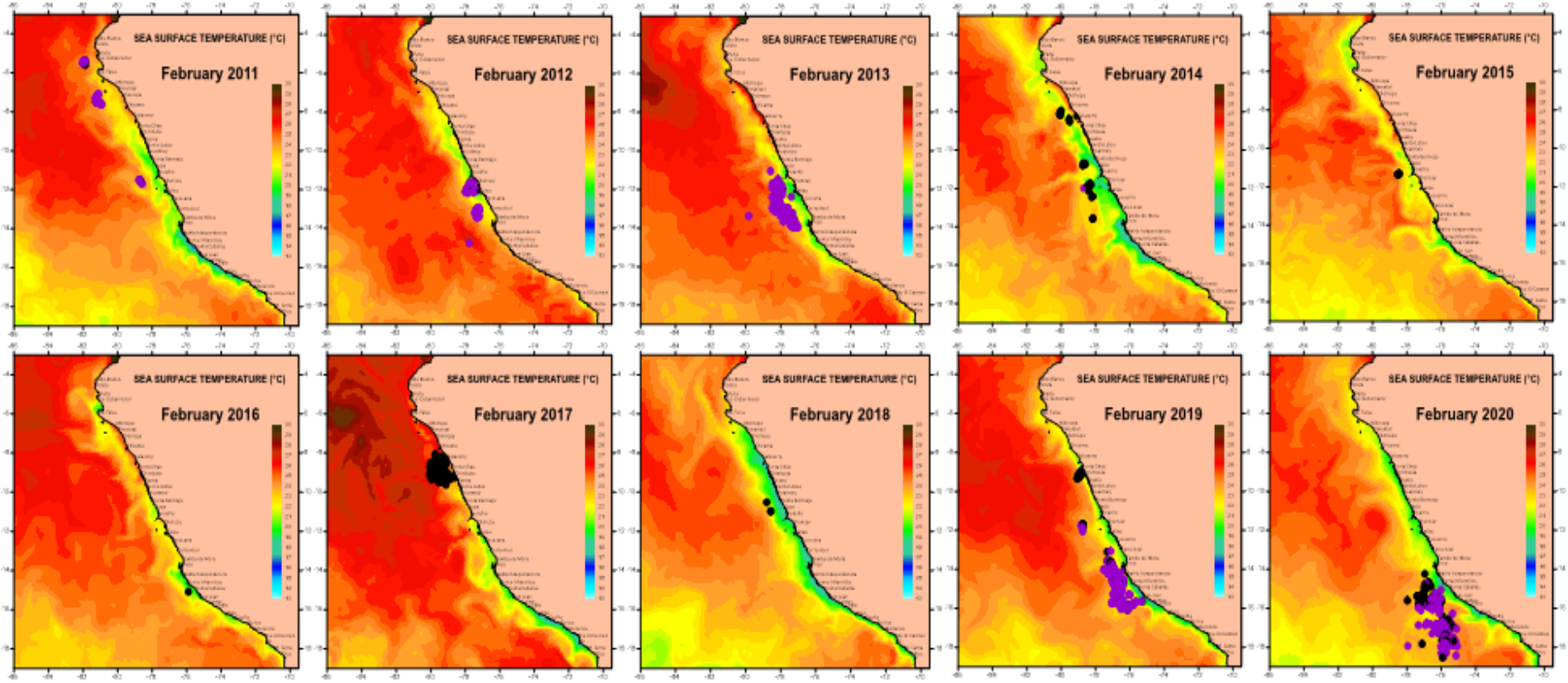

Figure 3.1.1. Mean sea surface temperature (°C) during February 2011-2020. Jack mackerel fishing sets made performed during February are indicated by purple circles, and with black circles in the case of chub mackerel. Source: SNP-IHMA.

3.2. Sea surface temperature anomaly (SSTA, °C)

In Figure 3.2.1. The mean sea surface temperature anomaly (SSTA) is presented for February as a proxy of summer conditions between years 2011 and 2020, indicating the location of the jack mackerel and chub mackerel fishing sets (represented by symbols). The objective is to appreciate the changes in thermal anomalies that have occurred in the last decade and their possible relationship with the distribution and abundance of jack mackerel and chub mackerel.

Summers from 2011 to 2014 were characterized by negative values of SSTA near the coast, with an ocean front between CCW and SSW which constitutes a suitable habitat mainly for jack mackerel. In contrast, years 2015 to 2017 were characterized by high thermal anomalies due to the fact of El Niño-like events that took place in those years, a weak one during 2015-2016, and a moderate one during 2017. These conditions are not considered favorable for jack mackerel, but favorable for chub mackerel, whose habitat corresponds to warmer waters and distributed further north.

Between 2018 and 2020, cold conditions were observed again in a coastal strip along the coast, but with relatively high thermal anomalies in the neighboring area of the south-central region. During summer 2020, a fundamental difference was observed compared to previous summers, since the presence and availability of jack mackerel and chub mackerel occurred over nuclei with positive thermal anomalies in the southern zone, which is unusual at least for the season.

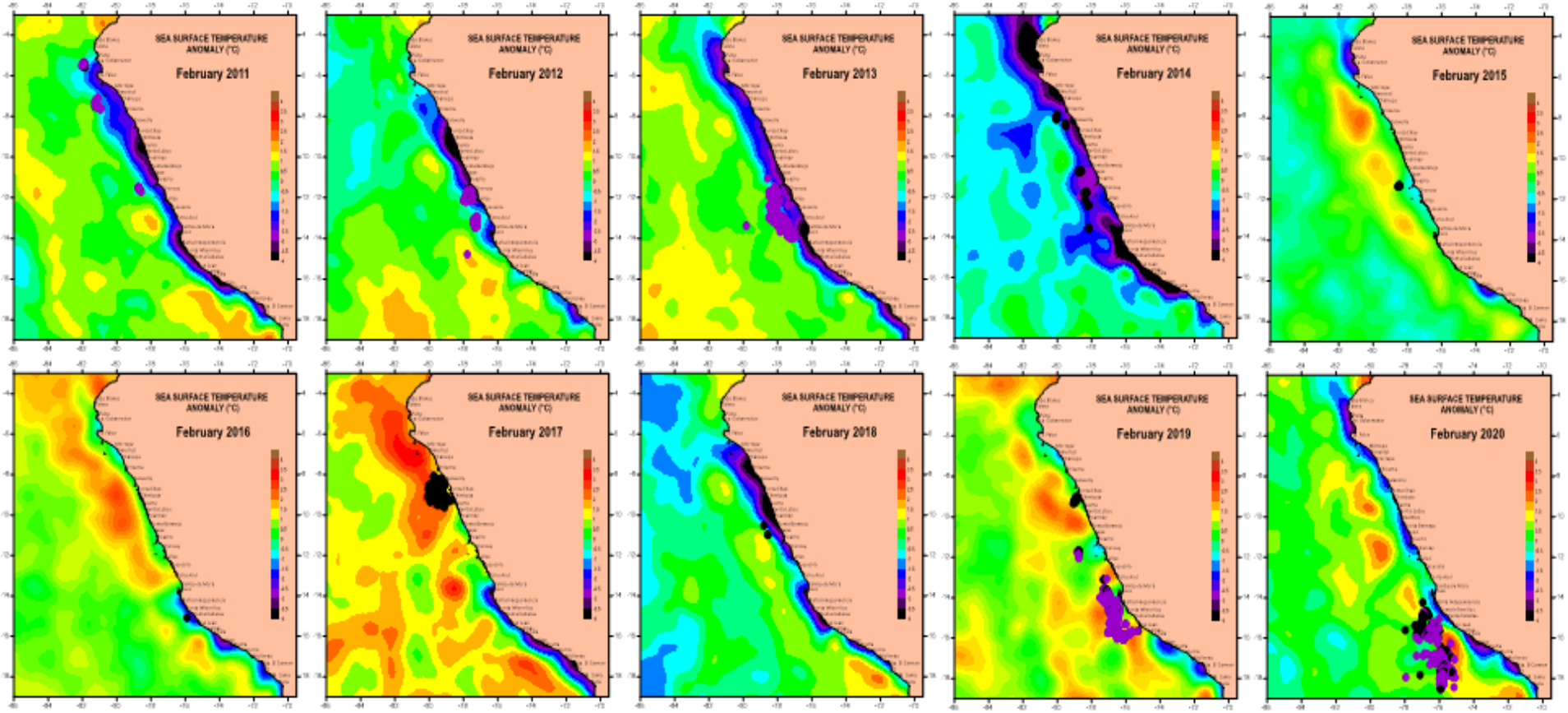

Figure 3.2.1. Mean sea surface thermal anomaly (SSTA, °C) during February months from 2011 to 2020 as a proxy of summer conditions. Fishing sets for jack mackerel are indicated by purple circles purple, and by black circles in the case of chub mackerel. Source: SNP-IHMA.

3.3. Sea level anomaly (SLA, cm)

In Figure 3.3.1. mean sea level anomaly (SLA, cm) during February months for years 2011 and 2020 is presented as a proxy of summer conditions, and with indication of fishing sets performed for jack mackerel and chub mackerel (indicated by symbols). SLA maps are presented in order to appreciate the changes in summer dynamics that have occurred during the last decade and their possible relationship with the distribution and abundance of jack mackerel. and chub mackerel.

Between 2011 and 2014, SLA values between -2cm and 6cm were recorded. Between 2015 and 2018, higher SLA values were observed, which corresponded to a lower availability of jack mackerel, and a higher density of chub mackerel.

During summer 2019 a strong contrast was observed between SLA values in the southern zone, which matches an overlap of jack mackerel and chub mackerel fishing areas. During summer 2020 a different pattern was observed, this time with relatively high SLA values in the areas where a coincidence in the distribution of both species was again detected.

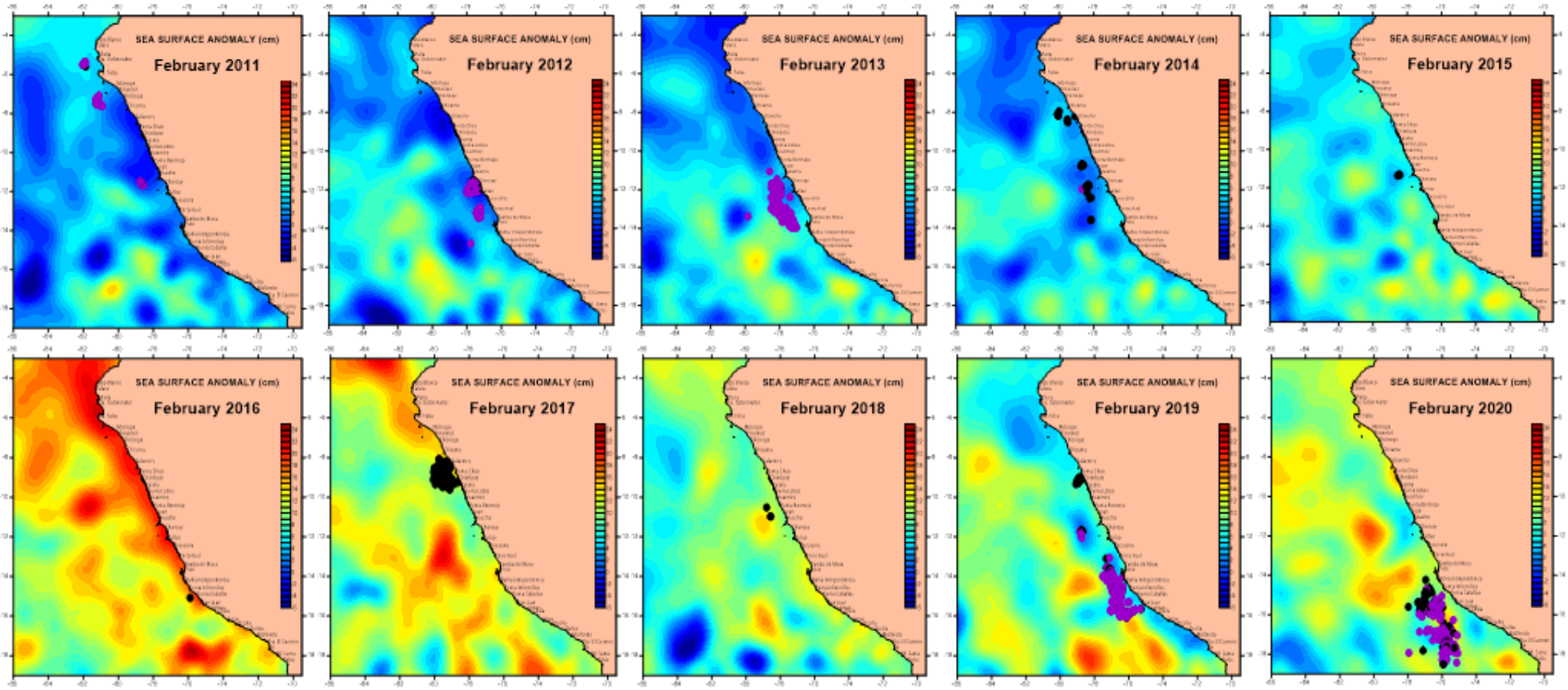

Figure 3.3. 1. Mean sea level anomaly (SLA, cm) during February months from 2011 to 2020 as a proxy of summer conditions. Fishing sets for jack mackerel are indicated by purple circles, and by black circles in the case of chub mackerel. Source: SNP-IHMA.

4. Catches of jack mackerel and chub mackerel between 2011 and 2020

Both jack mackerel and chub mackerel are species that exhibits a reputation of wide plasticity and adaptability to changing oceanographic conditions. For example, the thermal range in which they are distributed is wide, their feeding habits are often opportunistic, and their capacity to perform large displacements is evident.

However, due to its wide tolerance to different conditions, its potential habitat is also wide. In order to model their distribution and abundance, it is therefore essential to analyze fishing information given the impossibility of mobilizing scientific vessels to measure the various population parameters for both species in such a wide area. One of the basic aspects to analyze is to relate the catches to the various environmental variables that than can be modeled.

In Figure 4.1 the fishing sets of jack mackerel and chub mackerel made each year are shown together. In 2011, the fishing operations began during summer in the northern area, then moving to the south-central area. During 2012 and 2013 the fishing season began in January, and lasted until April; all the fishing sets were developed in the south-central zone.

In 2014, the jack mackerel and chub mackerel fishing season took place between January and April in the central and central-south areas. During 2015 to 2017 mostly chub mackerel was caught in the central-north region due to the development of El Niño-like events that are not favorable to the jack mackerel availability.

During 2018 the fishing sets were reported on almost the entire coastline, with a predominance of chub mackerel in the central-north region. Finally, during 2019 and 2020 the fishing sets were located in the south-central zone, mainly south of Pisco.

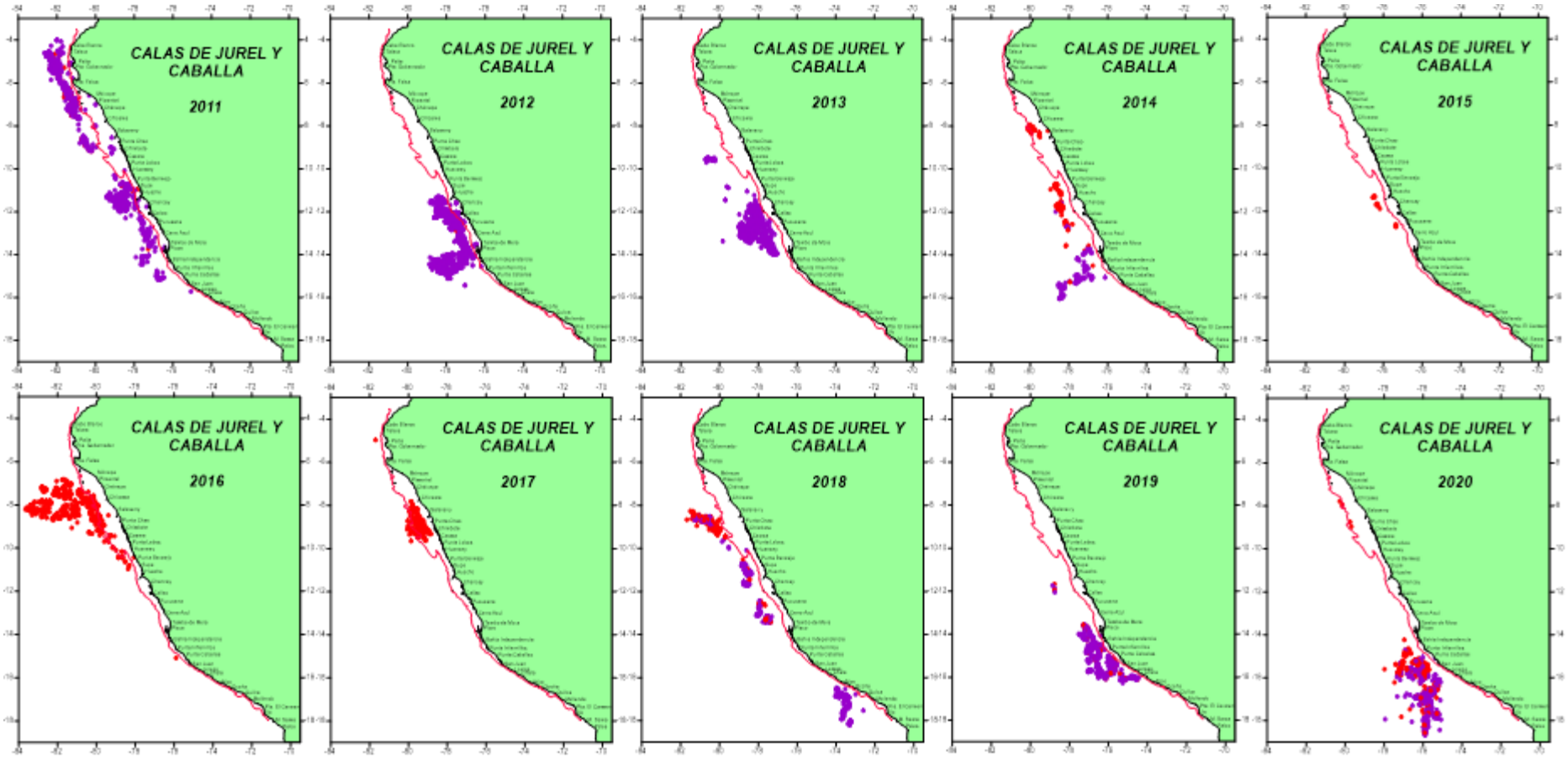

Figure 4.1. Distribution of fishing sets performed by the industrial fleet targeting jack mackerel (purple circles) and chub mackerel (red circles) during 2011 to 2020.The outer limit of the continental shelf is shown in a red line. Source: SNP-IHMA.

In figure 4.2. the catches of jack mackerel and mackerel are presented between the years 2011 and 2020; these number are not official and are referred to the catches obtained by the fishing companies associated to SNP. It can be observed that years 2011 to 2012 were favorable for the fishing of jack mackerel, and to a lesser extent for chub mackerel. Years 2015 to 2017 were favorable for chub mackerel, which is partially explained by the occurrence of El Niño-like events, which are periods that are -in general- negatively correlated with the availability of jack mackerel. During 2019 and 2020, a positive trend in the availability of both species has once again been observed.

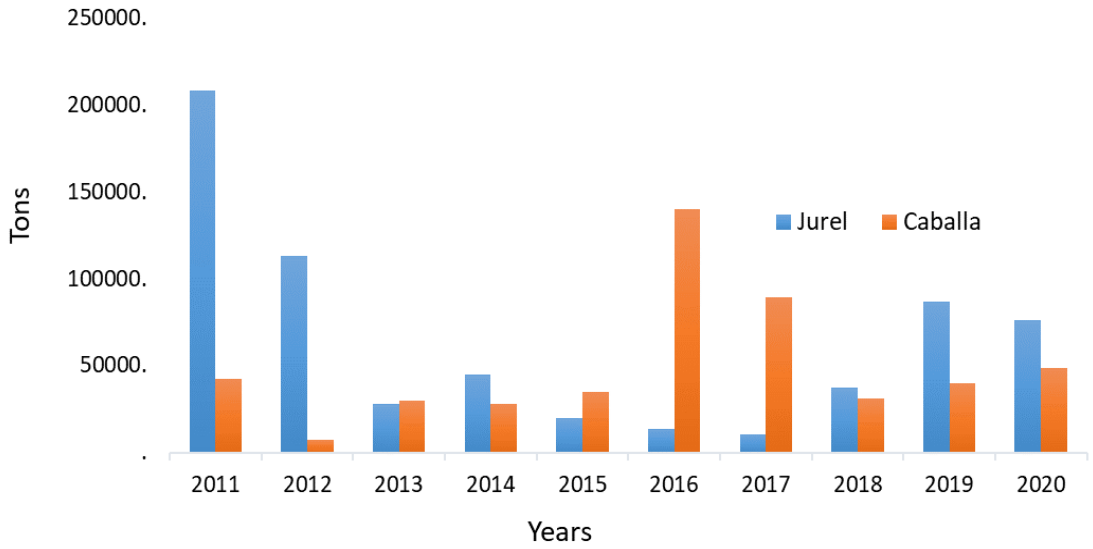

Figure 4.2. Catches of jack mackerel and chub mackerel between years 2011 to 2020. Source: SNP-IHMA.

There is a strong seasonality in the catches of jack and chub mackerel, although this is not only due to the higher availability of these species during summer months, but also to the fact that during a larger part of the April-January months the anchovy fishing seasons take place. The fleet authorized to fish jack and chub mackerel also participates in the anchovy fishery. However, during the recent decade there have been years in which jack mackerel and chub mackerel have been caught in other months, for example during October 2019. Figure 4.3 shows the catches by summer months (January to March) for years 2011 to 2020; It can be seen that, at least for the recent most years, the best catches have been obtained during February.

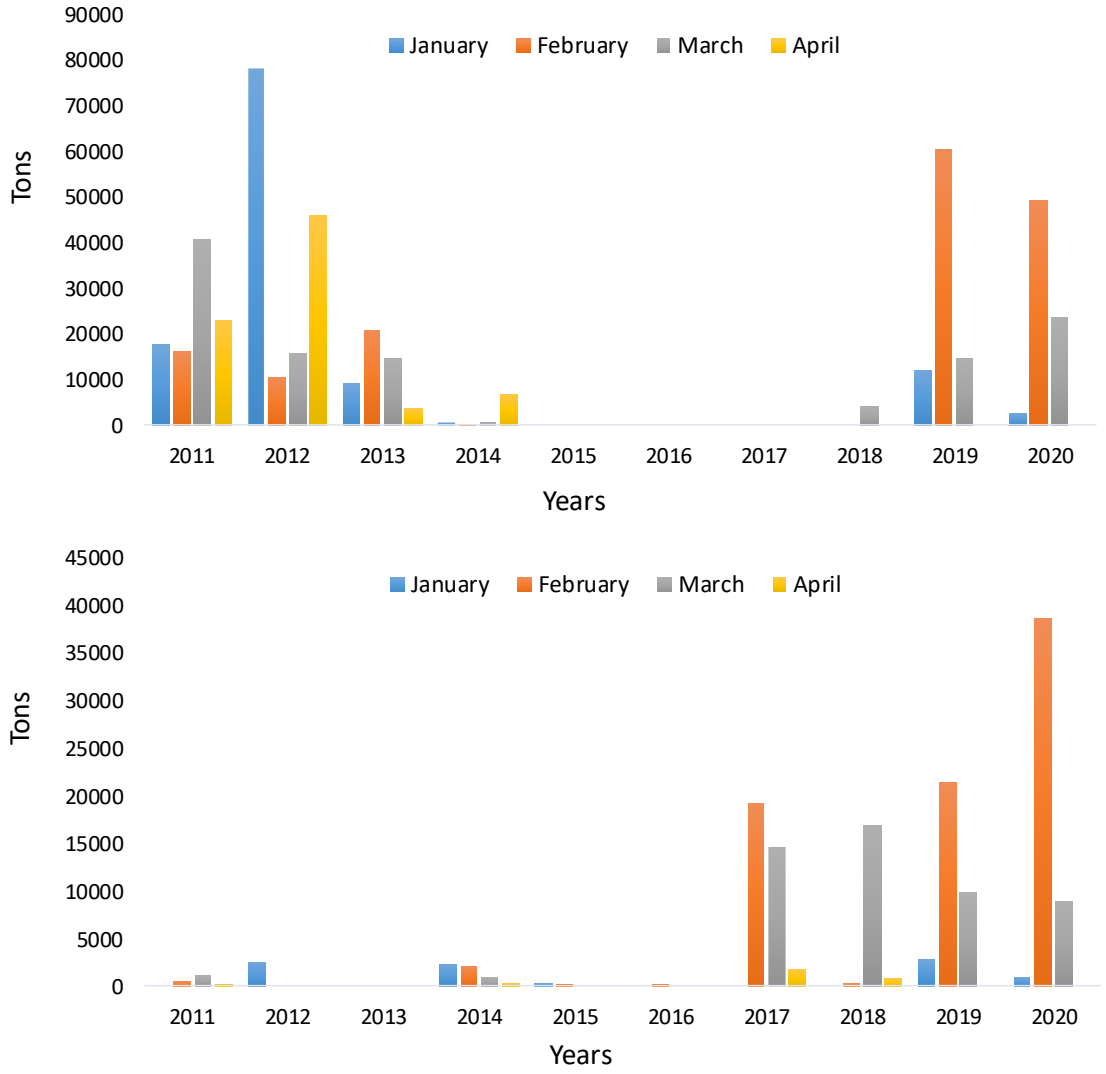

Figure 4.3. Catches in metric tons (MT) of jack mackerel (upper panel) and chub mackerel (bottom panel) between months January to April between years 2011 and 2020. Source: SNP-IHMA.

5. Size structure of Jack mackerel and Mackerel between 2011 and 2020

5.1. Jack mackerel size structure

Between years 2011 to 2020, jack mackerel sizes fluctuated between 24 and 43 cm in total length. Several size modes have been observed as shown in figure 5.1.1.

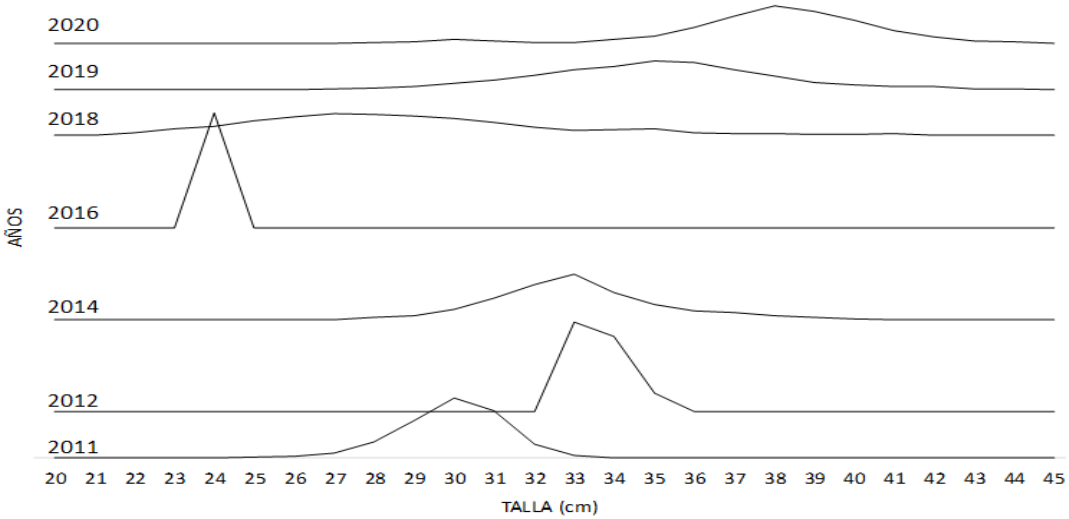

Figure 5.1.1. Size structure of jack mackerel from 2011 to 2020. Source: SNP-IHMA.

5.2. Chub mackerel size structure

Between 2011 and 2020, chub mackerel sizes fluctuated between 20 and 43 cm in total length, with several modes observed over time. See figure 5.2.1.

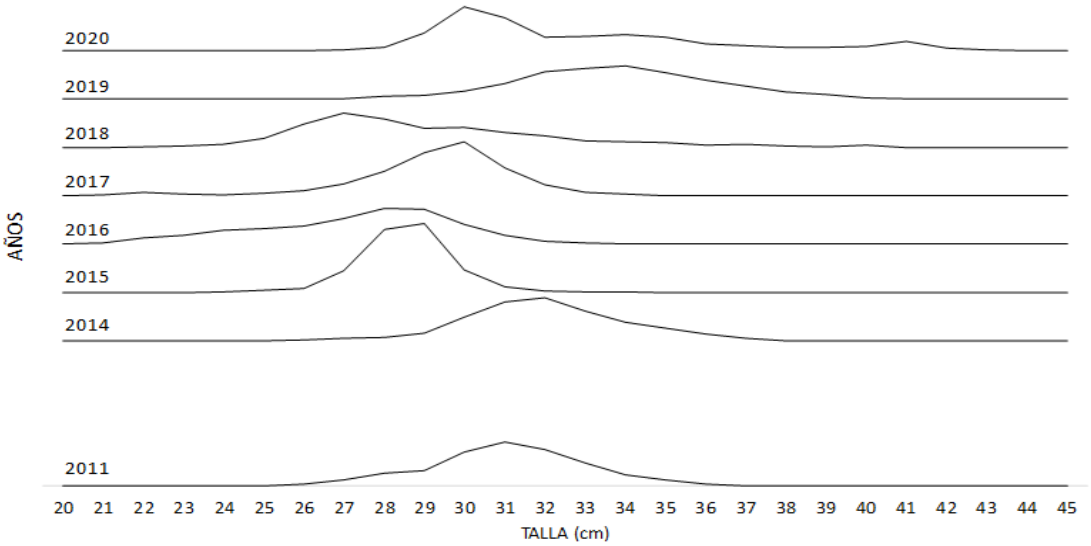

Figure 5.2.1. Size structure of chub mackerel between 2011 and 2020. Source: SNP- IHMA.

6. Abundance of jack mackerel and chub mackerel using acoustic and geostatistical methods

Since the first jack mackerel habitat workshop held in 2011, two methods have been used to estimate jack mackerel and chub mackerel abundance. One of the methods was acoustic. A certain number of vessels participating in the fishery are equipped with digital 120 kHz frequency systems (echo sounders), and have collected acoustic data to analyze and quantify fish abundance. These estimates have not been able to be updated every year due to the difficulty of gathering, handling and analyzing large volume of data.

The second used method used is geostatistical, through which all the fishing sets for both jack mackerel and chub mackerel have been regionalized in 8 zones, in order to calculate the centers of gravity and inertia associated with each region. Likewise, the catches data has been subdivided into time periods (fortnights). The average catches by area and by time period have been used as an indicator (proxy) of the abundance of jack mackerel and chub mackerel.

The used methods are described in detail in SNP (2015[3]).

6.1. Acoustic biomass of jack mackerel (*Trachurus murphyi*)

Figure 6.1.1 presents a hovmoller diagram of the changes in jack mackerel latitudinal acoustic biomass between 1983 and 2020 using IMARPE's data (www.imarpe.gob.pe). Two regimes can be observed: one between 1983 and 2002, in which the biomass fluctuated between medium and high levels; and another regimen after 2002 with abundances varying between medium and low levels. In recent years a positive trend has been observed in biomass, that is, an increase towards medium levels of biomass.

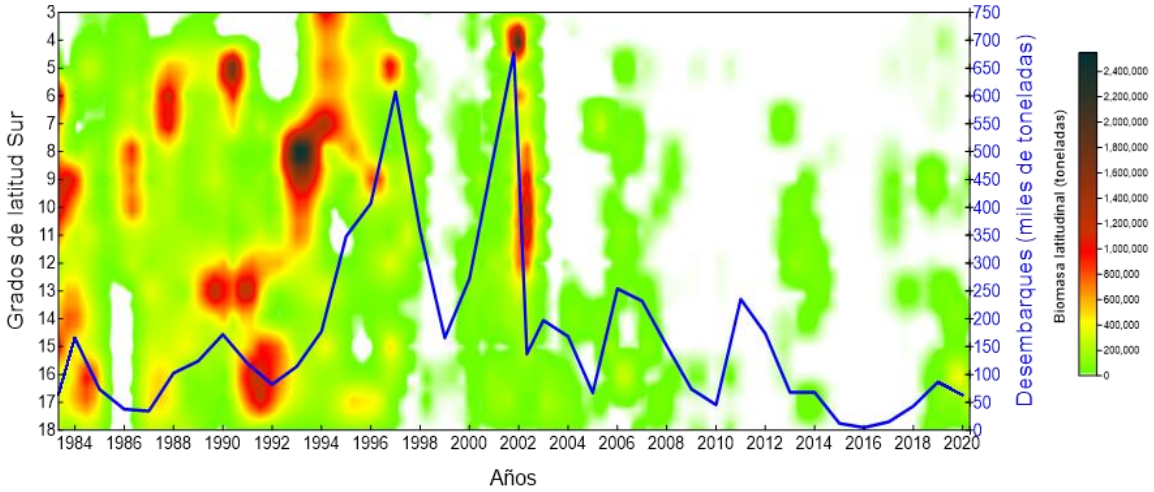

Figure 6 .1.1. Latitudinal jack mackerel acoustic biomass along the Peruvian coast represented by the vertical axis on the left between 1983 and 2020 (horizontal axis). Annual catches are represented by the blue line and the right vertical axis. The colors correspond to biomass according to the legend on the right side of the figure. Source: IMARPE-IHMA.

[3] SNP.(2015). Informe del VI Taller de Evaluación del Estado del Recurso jurel *Trachurus murphyi*. Comité de Investigación Científica (2,3 y 4 de setiembre de 2015).

6.2. Jack mackerel abundance calculated by a geostatistical method

As can be seen in figure 6.2.1. the highest abundances of jack mackerel occur in two periods: between 2011 and 2014; and from 2018 to 2020. The warm environmental conditions between 2015 and 2017 were characterized by low catches of jack mackerel. In the first period, the highest abundance has been calculated in March 2001 with 380,000 tons. In the second period, the highest abundance was calculated in February 2019 with over 500,000 tons. It is necessary to reiterate that these numbers correspond to calculations made based solely on the catches of the industrial fleet that operates outside the first 10 nautical miles from the coast. In Peru there is also an artisanal fleet that catches jack mackerel, but its catches have not been incorporated into this analysis.

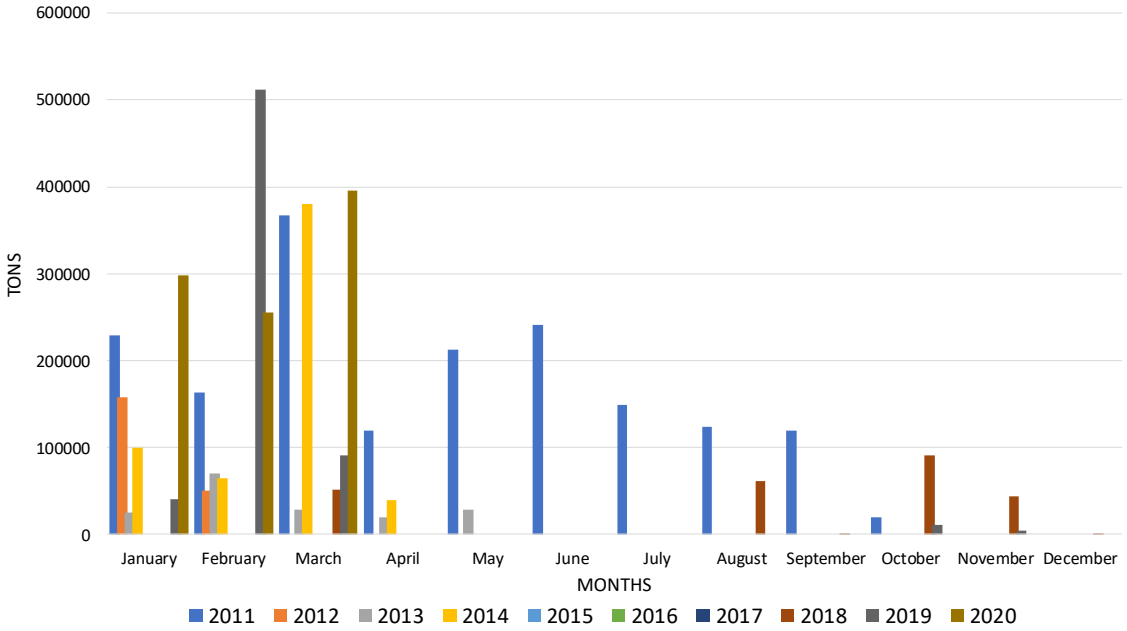

Figure 6.2.1. Jack mackerel geostatistical abundance between 2011 and 2020. Source: SNP-IHMA.

6.3. Acoustic biomass of chub mackerel (*Scomber japonicus*)

Figure 6.3.1. presents a hovmoller diagram of the changes in chub mackerel latitudinal biomass between 1983 and 2020 using IMARPE's data (www.imarpe.gob.pe). In general, three regimes are observed: the first occurred between 1983 and 1992, in which the biomass presented medium levels and a uniform distribution along the entire coast; the second regime occurred between 1992 and 2002, in which the biomass fluctuated between medium and high levels; and a third regimen occurred after 2002 with abundances varying between medium and low levels. However, a positive trend in biomass can be observed in recent years, that is, an increase towards medium levels of biomass.

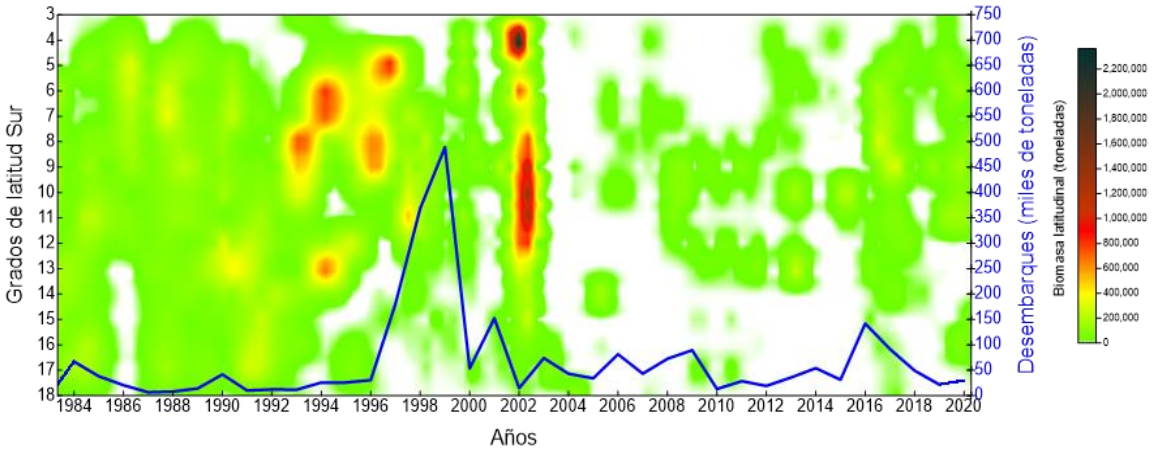

Figure 6.3.1. Latitudinal acoustic chub mackerel biomass along the Peruvian coast represented by the vertical axis on the left between 1983 and 2020 (horizontal axis). The catches are represented by the blue line and the right vertical axis. The colors correspond to biomass according to the legend on the right side of the figure. Source: IMARPE-IHMA.

6.4. Chub mackerel abundance calculated by a geostatistical method

In figure 6.4.1. they are shown the calculated abundances of chub mackerel using a geostatistical method (tons) by months between 2011 to 2020. The highest abundances of chub mackerel were estimated during August 2016 with over 800,000 tons, followed by March 2017 with over 700,000 tons.

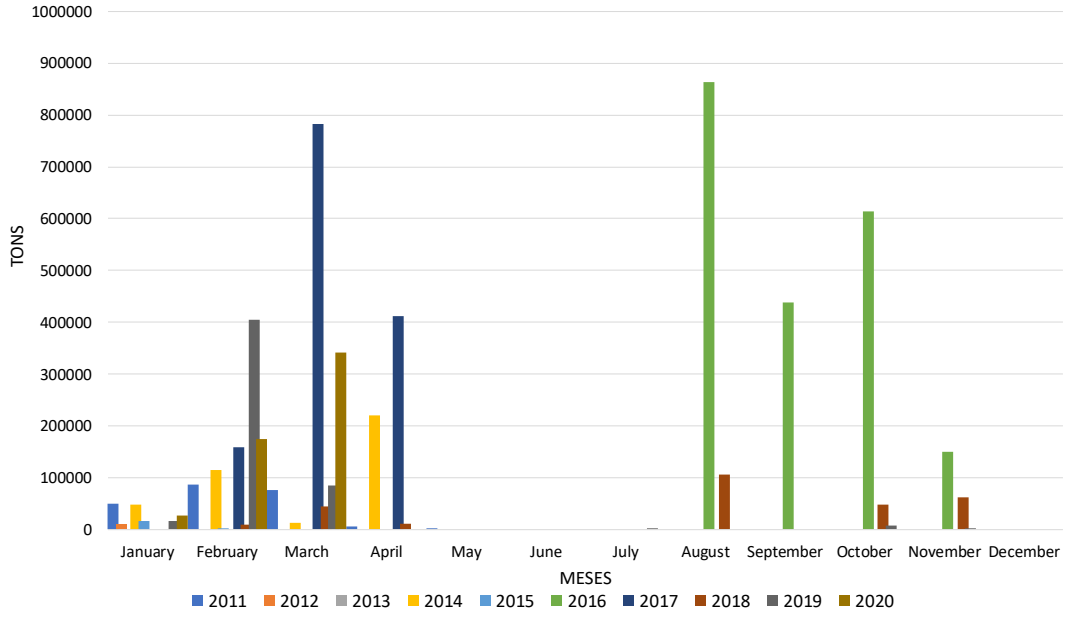

Figure 6.4.1. Mackerel abundance and catches between 2018 and 2020. Source: SNP.

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