

**7<sup>th</sup> MEETING OF THE SCIENTIFIC COMMITTEE**

*La Havana, Cuba, 7 to 12 October 2019*

**SC7-JM02**

**Space-time dynamics of Chilean jack mackerel fishery  
from South-central Chile in 2019**

*Chile*

# **Space-time dynamics of Chilean jack mackerel fishery from the South-central Chile in 2019 versus 2017-2018.**

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## **Abstract**

The fishing season of 2019 (January-July) show significant changes in the spatial and time distribution of the Chilean jack mackerel and its commercial fishery that were observed in coastal areas and the high sea regions off South-central Chile. These changes were more relevant in the high sea fleet, unlike other years (2017-2018), where between March-June 2019 the operation was exclusively over dispersed jack mackerel concentrations, of sizes larger than 38- 40 cm FL (mode displaced to 44-46 cm), and spatially isolated from those distributed in the Chilean coastal zone with a practically non migrating jack mackerel. Similarly as fishing season 2018, jack mackerel was concentrated in very close to the coast areas, especially in January-March, has an inter-monthly stability in size structures (polymodal, several modes), with a reduced participation of fish <26 cm FL. In July there was a clear movement offshore in direction to 36-37°S / 77-78°W, similar to 2018. It is assumed that stability of Chilean fishery and concentrated jack mackerel distribution in 2018-2019 can be related to the initial stage of fishing season (December-March) because there is a predominant cold oceanographic conditions (negative SSTA and/or neutral negative), in which no entry of concentrations of juveniles was observed, because the adult jack mackerel does not carry out the massive migrations southwards along the coast (south of 39-40°S) and / or towards the open waters outside the Chilean EEZ

Also in these years there is a productivity increase and concentration of food (euphausiids) precisely in concentrated jack mackerel areas where, in addition, since second half of 2018 there is an absent of jumbo squid in sizes above 60- 70 cm ML. A low intensity of adult jack mackerel emigrations to open sea (especially in 2019) is a determining factor of a reduced presence (2018) or total absence (2019) of jack mackerel on the open sea. This is different in warm years, as was 2017. In this year towards the coast and in the south direction there is a massive approach (with warm subtropical waters) of juvenile jack mackerel (<26 cm FL), the distribution of these fish and adult fish is more coastal and wider latitudinal, massive migrations of adult jack mackerel are detected towards south and open sea. The monthly structure of fish sizes is variable. However, in the oceanic area the spatial dynamics of jack mackerel and fleet fishing operations, as well as the size structure of fish in catches are more stable during this year.

## 1. General Background

Currently, after a long period (2002-2012) of contraction of the distribution area and decrease of abundance in the South Pacific at a critical level (years 2011-2013), the Chilean jack mackerel resource shows recovery signs that is reflected in the biologic-fishing indicators of the population as well as in the space-time dynamics of Chilean and international fleet operations. From 2012-2013 the distribution of jack mackerel and fisheries are concentrated mainly within the Chilean EEZ (Chilean fleet) and / or along the limit of the Chilean EEZ (in the case of international fleet), with the extension of its area towards the open ocean up to 82-84°W and some months, up to 90°W (Figure 1).

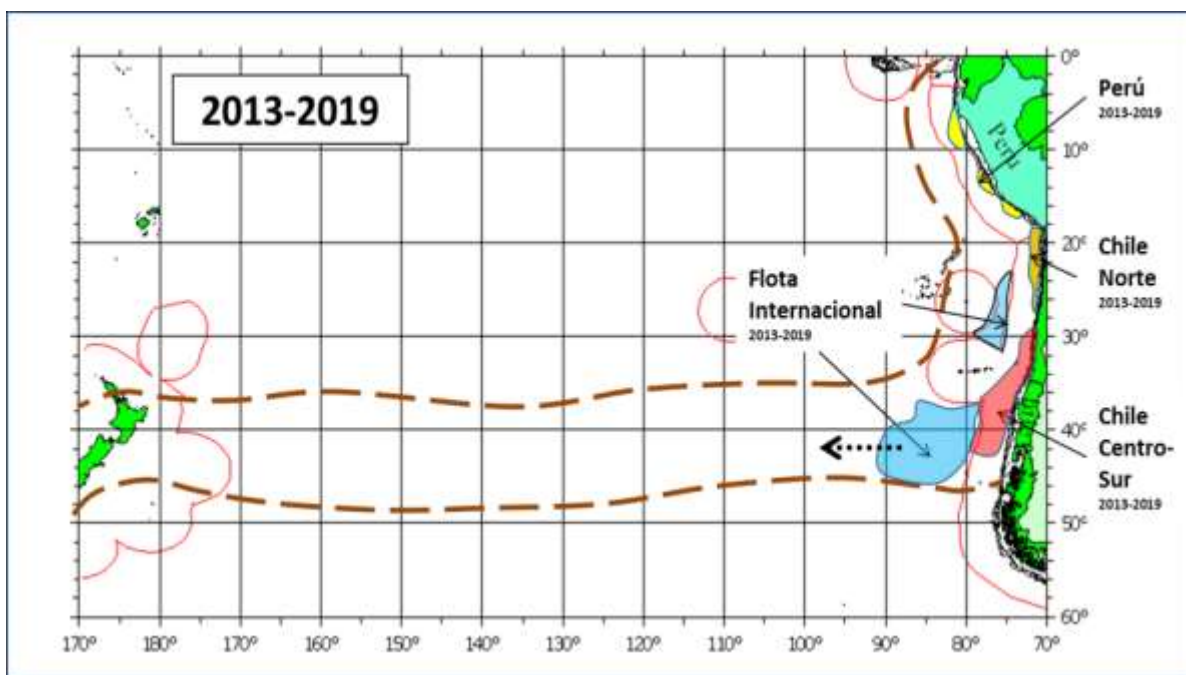


Figure 1. Scheme of the main areas of fishing operations of the fleets on Chilean jack mackerel resource in the South Pacific between 2013-2019.

On the other hand, the distribution and availability of the jack mackerel resource in front of the Chilean coasts are characterized by their marked seasonality within an annual fishing season dependent on both habitat conditions (oceanographic conditions) and the physiological fish condition at different stages of its annual life cycle (Gretchina et al., 2018).

Towards south-central Chile coastal waters, the first concentrations of jack mackerel appears during December, the entry time coincides with the initial stage of seasonal water heating in the region reflected in the entrance with a broad front of subtropical warm waters of the open ocean towards the coasts. In this case, adult jack mackerel enters advanced maturation and / or post-spawning, as is assumed from the oceanic spawning area to fattening in coastal areas of high biological productivity. Jack mackerel concentrations

migrate actively to south-southwest along the coast. At the same time in fishery, with the further advance of subtropical front towards coast, appears juvenile fish of sizes smaller than 26 cm FL, which also tend to be distributed to the south. About the latter subject, to a lesser or greater way, it is repeated for at least last 5 years. From March-April, jack mackerel concentrations begin their fattening migrations along the coast from south to north; it coincides with the beginning of seasonal strengthening of the sub-Antarctic cold water flows from the SW-S. From July-August, jack mackerel migrations are activated towards to warmer oceanic waters, towards the N-NW of the region, towards the oceanic zones of their future spawning.

In the open ocean, outside EEZ of central-southern Chile, where the international fleet operates and where the western limit of jack mackerel distribution is located, the first concentrations in active fattening and larger sizes (> 40 cm FL) are found from the end of February-March between 84-87°W and south of 44-45°S. From April-May the fleet is concentrated on the jack mackerel in the vicinity of the 200 nm line of the coast, in the jack mackerel of the coastal waters of Chile, it moves gradually from the south (43-44°S) north to along this line to meet the limit of the insular EEZ (Juan Fernández Islands) at 37°S / 78°W towards the end of July-August. This fishery exit route of jack mackerel (to north-northwest by Chilean waters) is established from 2012-2013, is different from that registered during years 2002-2011, when resource emigration had a well-defined route to the NW-W, to disperse in spawning between 90-120°W approximately in October-November (Pastoors & Hintzen, 2018).

After this date, jack mackerel concentrations enter to EEZ and the international fleet leaves the southern region and moves northward, towards the region of “La Bota” located between the continental and insular EEZ (San Felix Islands and San Ambrosio), between approximately 24-30°S. In this area, the fleet operates mainly in small fish (17-28 cm FL) outgoing from the coast, between the months August-September - October-November. Both annual cycles in the jack mackerel distribution, reflected in the fishing operations of both fleets (coastal and open sea), are repeated with some modifications between the years.

## **2. Jack mackerel fishery in 2019 versus 2017-2018**

On the part of SPRFMO for Chile for the years 2017, 2018 and 2019, the annual global quotas for jack mackerel catching were 317,300 t, 371,887 t and 381,572 t. Which, with transfers between countries, in these years present annual final values of 351,521 t for the year 2017, 427,264 t for the year 2018 and 443,137 t for the year 2019. A higher percentage of these quotas in Chile are captured by the industrial fleet of central-south Chile. In this region the fleet has captured in 2017 (January-December) 281,736 t, corresponding to 80.15% and 2018 (January-December) 392,778 t, 91.93%, and 2019 (January-August) 385,871 t, corresponding to 87.08% of the country's annual global final share. The monthly dynamics of jack mackerel catches in central-south Chile for 2017-2019 periods is presented in Figure 2.

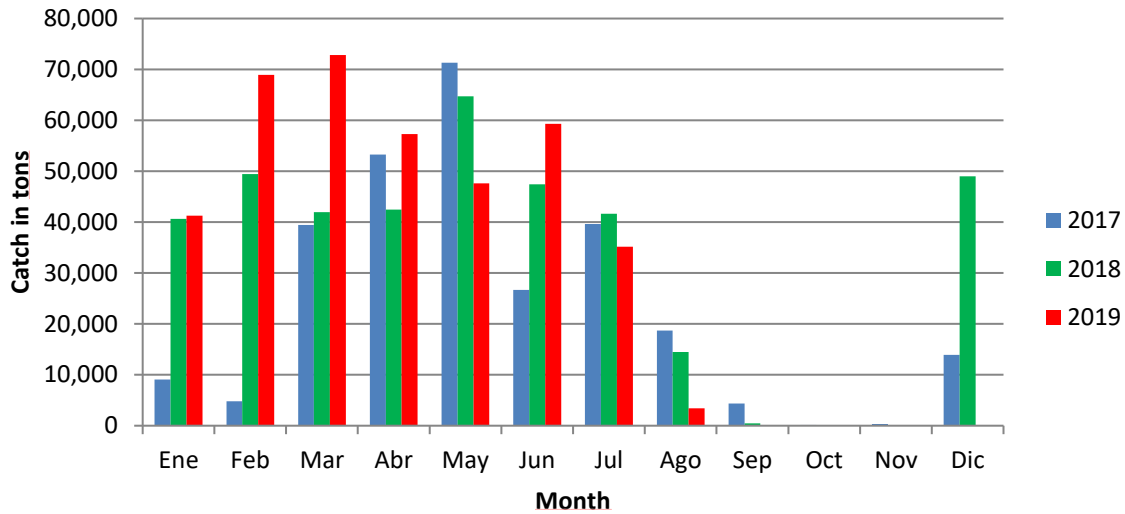


Figure 2. Monthly jack mackerel catches of industrial fleet of south-central Chile in 2017, 2018 and 2019 (until August). Source: INPESCA.

As it is possible to see (Figure 2), the monthly jack mackerel catches in the south-central Chile region in January-July 2019, as in the same period of 2018, are higher or close to 40,000 t per month, become in February-March 2019 over 68 thousand t; In 2018, only during May the catches exceeded 70 thousand tons per month. This is not the case during the year 2017: they are low in January-February (addition of two months of 13,872 t), close to or over 40 thousand t in March-May and June, with a decrease to <30 thousand t.

The low jack mackerel catches in January-February 2017 are related to the massive presence of juvenile fish (<26 cm FL, under legal minimum size) in the fleet operation areas. This has forced to the fleet to decree self-closure fishing in these months. This is not the case during the beginning (January-February) of fishing seasons of 2018 and 2019, when the percentage of small jack mackerel in catches was much lower than that allowed by law (<35% in number). The absence and/or low presence of jack mackerel juveniles in the fleet's catches determines a stability and continuity of regional fishery, which is regulated not by the resource availability in fishing areas, otherwise by the necessity of processing plants.

It is also interesting to note that under the conditions of annual jack mackerel regulations by SPRFMO and which for the center-south Chile fleet between 2012-2019 fluctuated between 200 and 390 thousand tons, it is observed a clear trend towards the progressive growth of the fishing yields of jack mackerel + chub mackerel especially in 2017-2019 (Figure 3). This may be an indicator of a greater availability of the resource for the fleet that every year is achieving greater catches with less effort involved, achieving in advance the fulfillment of the annual fishing quota during the first 6-7 months of the year.

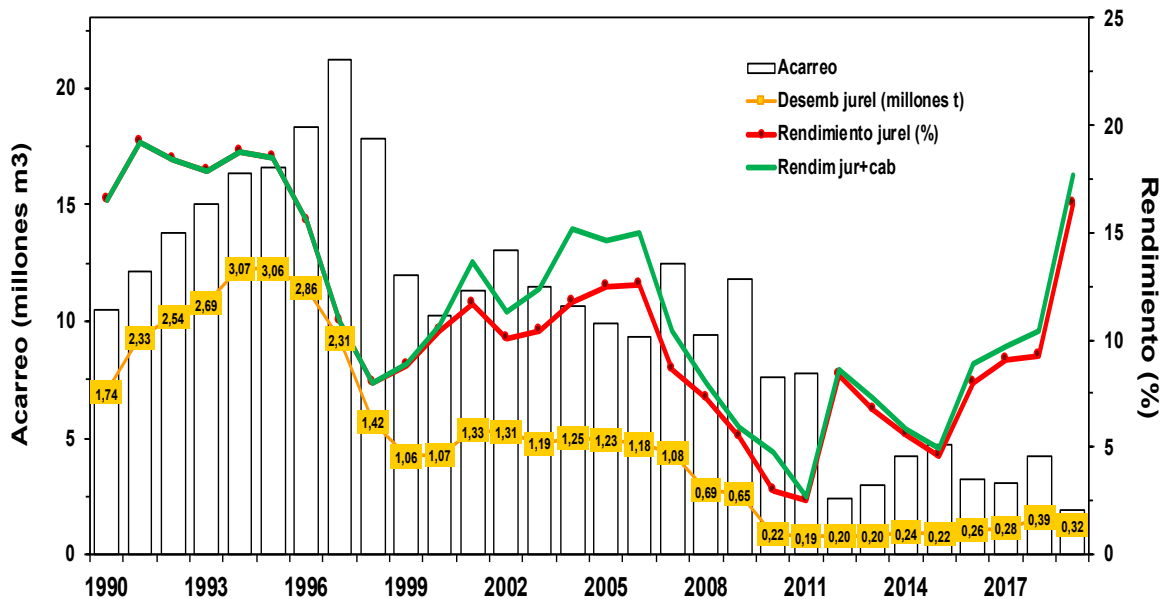


Figure 3. Annual dynamics of catches, hauling and yields of the industrial fleet of central-south Chile that operates in the resources of jack mackerel and / or jack mackerel - Mackerel between 1990-2019 (until June). The annual yields of jack mackerel and jack mackerel + mackerel are estimated by dividing the catch by haul. Effort is calculated by multiplying the Hold Capacity by Days Outside Port (HCxDOP). The standardized catch per unit of effort (CPUE) of the central-south fleet is based mainly in this indicator and is an index of abundance, being the most relevant estimator in determining the biomass levels of the resource in The South Pacific.

On the other hand, in the open waters the jack mackerel catches of the international fleet drop sharply between 2010-2011, from 254, 5 thousand t to 60.9 thousand t, respectively, they remain at an average level between 2011-2016 in 57, 8 thousand t, after the fishing out of the Vanuatu fleet in 2016, at an average level of approximately 42 thousand t between 2017-2019 (Figure 4). In the last three years in the region there are only 5-6 vessels operating, which belong to the EU, China, Korea and Russia. However, these achieve total annual catches of less than 40% of the annual quota allocated to these countries by SPRFMO.

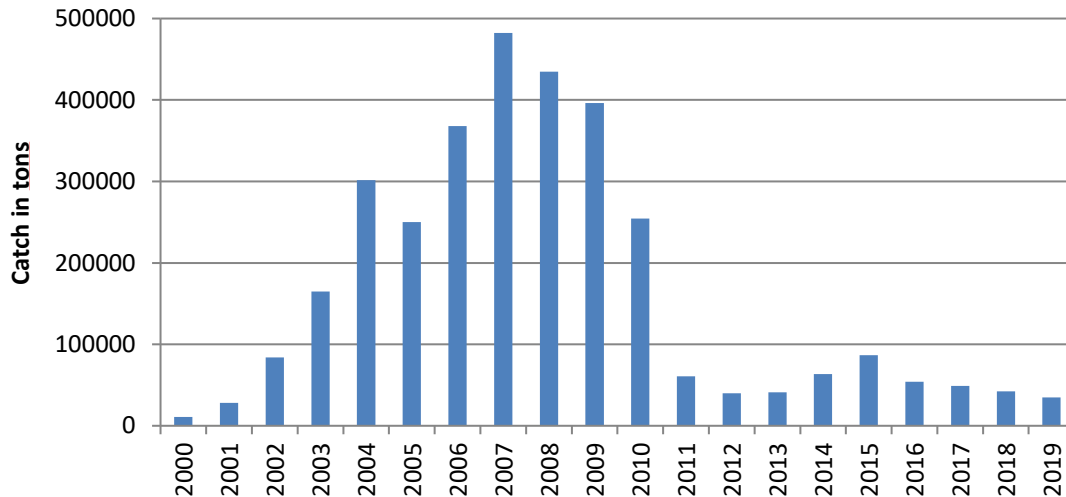


Figure 4. Dynamics of the annual jack mackerel catches of the international fleet in open waters of the South Pacific between the years 2000-2019. Year 2019 - approximate value is 35,000 t (reported for July 2019 = 28,658 t).

### 3. Space-time dynamics of distribution and structure of jack mackerel sizes in 2019 versus 2017-2018

The jack mackerel fishing season of 2019 in front of the coast of central-southern Chile starts from the first days of December 2018 when post-spawning concentrations of fish from the open sea (N-NW of the region) begin to enter to the coasts. These are subsequently concentrated in a well-defined area between 37°30'-39°S and 73°45'-74°40'W (Figure 5) and, in this, the regional fleet between December 2018 and March 2019 achieves a cumulative jack mackerel catch exceeding 240 thousand tons, only in three months of 2019, more than 50% of the annual global quote of the country.

The spatial distribution of commercial jack mackerel concentrations in these months coincides with the marked position of warm water thermal front located parallel to the coast and outside from the cores of the coastal upwelling, especially in January-March 2019 (Figure 5). Despite concentrated distribution of jack mackerel in the indicated area for four months, fish migrations further south of 39°S along the coast are not ruled out. On this you can say the monthly dynamics of jack mackerel sizes in the catches of the Chilean fleet between December 2018 and March 2019 (Figure 6, c). The specimens of sizes between 28-42 cm FL, with modes of 33-35 cm, enter in the same quadrant, then in the same quadrant predominate from sizes 26-34 cm FL, with modes of 28-30 cm (January-February 2019), that is, the fish that expel the previous group to the south, to change again in March to the similar structure of December, probably belonging to the pulse of fish already inbound from the south (Figure 6, c).



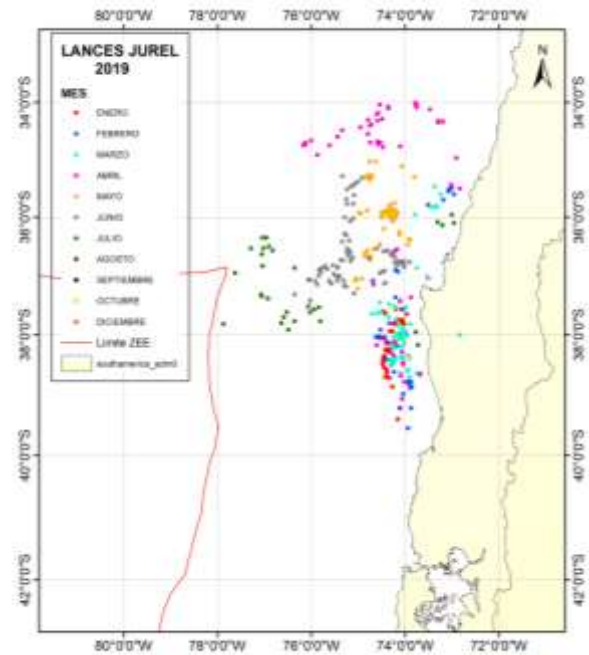


Figure 4. Spatial position of Chilean fleet fishing tows of jack mackerel between January- July 2019. Source: INPESCA.

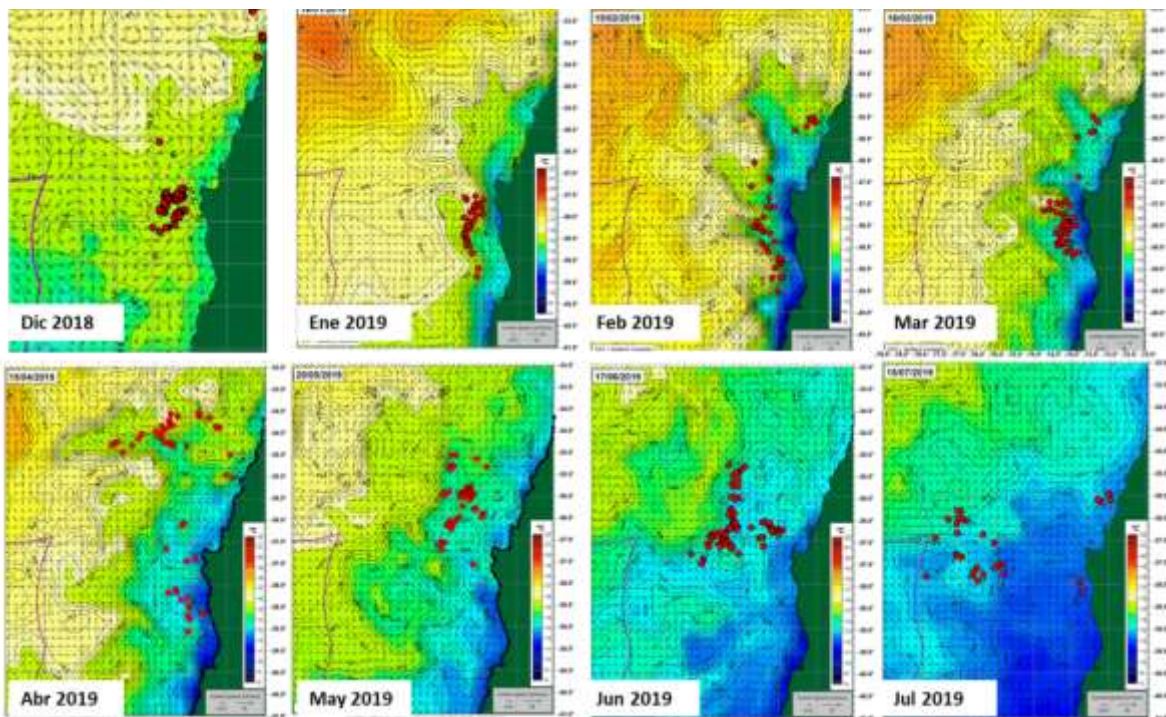


Figure 5. Spatial distribution of the fishing tows of jack mackerel of the Chilean fleet and the dynamics of associated TSM between December 2018 and July 2019. Source: INPESCA.



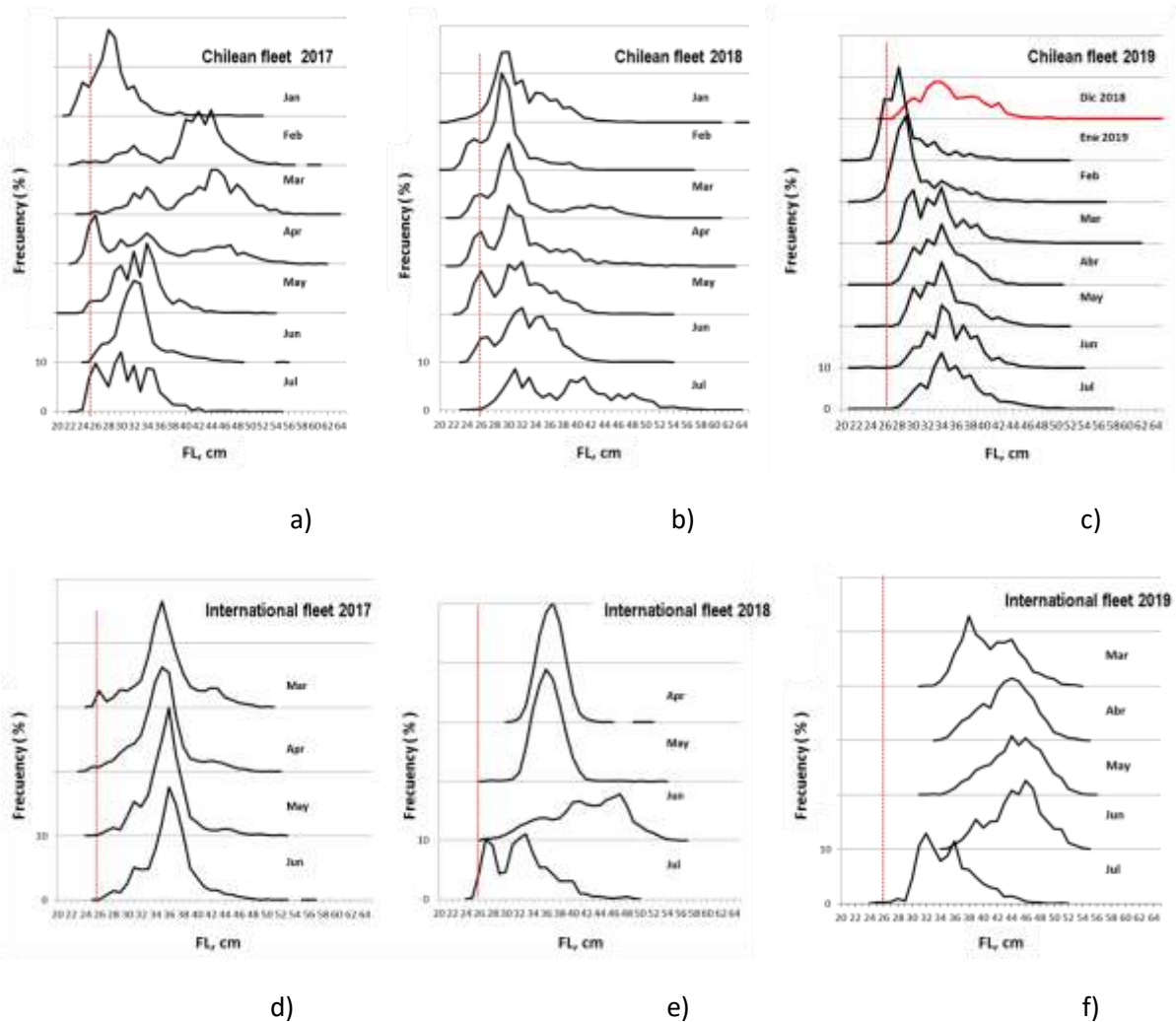


Figure 6. Jack mackerel size structures in Chilean (a, b, c) (INPESCA) and international (d, e, f) (reported by Russian and EU) fleets catches during years 2017-2019.

Since April, the coldest coastal water flows from the south are boosted both along the coast to the north and towards the NW-W of the region (Figure 4, 5). Also this expands the jack mackerel distribution area to N-NW-W directions. Despite this, commercial jack mackerel concentrations remain spatially associated (mostly) with frontal areas between colder coastal and warmer ocean waters (Figure 5, April-June). Only during July when almost all regional fisheries reach their respective annual fishing quotas, jack mackerel distribution is more chaotic and in the remote area of the coast, located near the limit of Chile's EEZ (Figure 5, July). It is estimated that in this area (approximately 36°30'S / 77°W), begin jack mackerel migrations to the oceanic zones of nearby spawning (Figure 7, c).

The monthly structure of jack mackerel sizes in catches between March-July 2019 is practically similar between the months. It fluctuates in a range between 28-30 and 42-44 cm FL, is multimodal, that is, it is represented by several generations of fish at the same time (Figure 6, c). The presence in fishery of juvenile jack mackerel specimens (<26 cm FL) during 2019 was minimal.

In general, the space-time dynamics of jack mackerel distribution in 2019 fishing season (Figure 7, c) was similar to observed in 2018, only that in 2018 the fishing areas are concentrated between January-June mainly in the quadrant of 37°S-40°S and the coast up to 76°W, with temporary displacement towards the south (up to 42°S) along the coast in the month of March and departure at the end of the fishing season (June) towards the spawning Oceanic by 36°S / 77°W (Figure 7, b) (Gretchina et al., 2018). This also reflects low inter-monthly variations in size structure of fish caught, only that during February-June, unlike 2019, it is observed an important contribution towards the fishery of the specimens between 24-28 cm FL, however, below what is allowed (<35% in number). In July fish between 38 and 50 cm FL because they come from coastal areas located near to Isla Mocha (38°30'S) (Figure 6, b).

On the contrary and with respect to 2018 and 2019, in 2017 the spatio-temporal distribution of commercial jack mackerel aggregations and the size structure of fish caught showed quite significant differences (Figure 7, a). This is mainly reflected in the fact that practically the entire fishing season of Chilean fleet operates on jack mackerel distributed in a fairly coastal strip, not exceeding 76°W west, both north and south of 37°S. On the other hand, in January-February 2017, jack mackerel juveniles entered abundantly. The entry of juvenile fish to the coasts of central-south Chile is related to a sharp advance in the same direction of subtropical warm waters, which the influence remained quite powerful until April-May, especially in the coastal areas located north of 37-36°S. For this reason, in the months of January, March, April, the fishing areas have a very coastal location and south-north displacement, as in the areas located south of 37°S in March-April (Figure 7, a).

The operational instability of the fleet in January-July 2017, determined, firstly, by a high presence in juvenile fish area, is also reflected in a high variability of the monthly structures of jack mackerel sizes in catches, mainly in the months of January-April, and it stabilizes only during May-July (Figure 6, a). The important presence in catches of the jack mackerel fleet of sizes larger than 38-40 cm FL in February-April (Figure 6, a) indicates that in these months the boats, avoiding juvenile fish fishing, have operated in the large jack mackerel in the very coastal areas adjacent to Mocha Island (38°30'S) and historically inhabits this sector (“resident jack mackerel” or “stone jack mackerel”). There are visible differences between the years 2017-2019 in the oceanic distribution of jack mackerel and the operational dynamics of the international fleet outside the EEZ of central-south Chile.

During 2017, between March and the beginning of August, jack mackerel fishing is concentrated exclusively along the EEZ limit, without exceeding 83-84°W, with a gradual displacement from 47°S in March until 37°S in July-August (Figure 7, a). During this period the structure of fish sizes in catches remains very stable, in a range between 26-46 cm FL, with modes between 34-36 cm (Figure 6, d). It is assumed that jack mackerel concentrations captured that year by the international fleet are outgoing from the Chilean EEZ.

During 2018, is maintained the same trend in distribution of jack mackerel outside the Chilean EEZ between March-May, that is, with the displacement along the 200 nm line of the coast in these months from 47-46°S to 42-41°S (Figure 7, b), presenting at the same time similarity in the structure of fish sizes, with fluctuations between 32-42 cm FL of

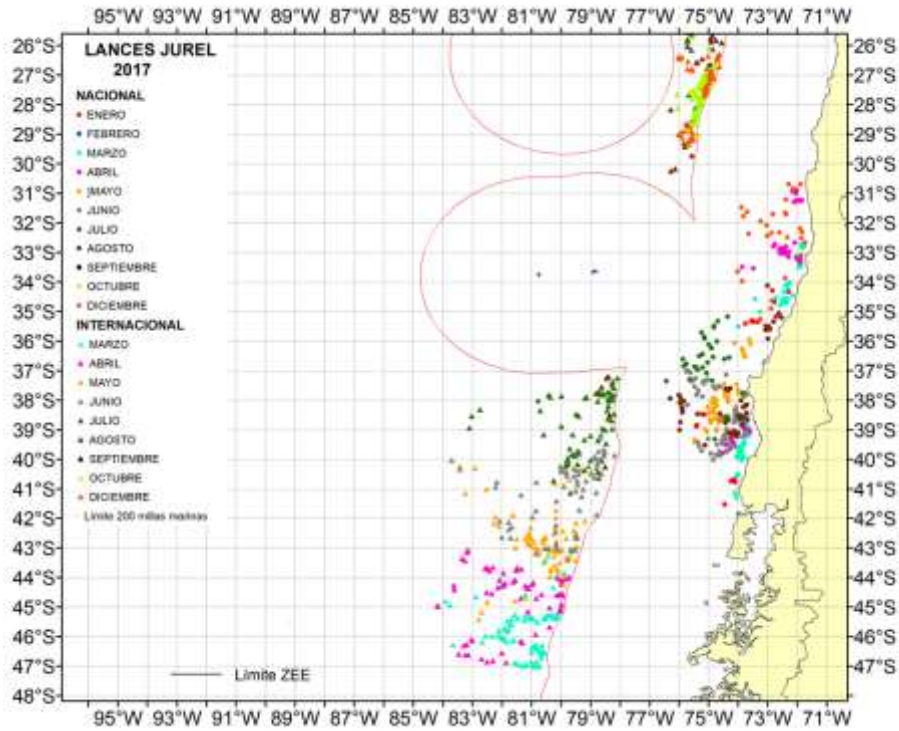
modal groups of 35-37 cm (Figure 6, e). However, during the month of June, highly likely, the concentrations of these fish migrate into the EEZ of Chile.

During June, in the conditions of almost total absence of fish near Chilean EEZ, in the area of approximately 40°S / 80°W, a jack mackerel mass of larger sizes, above 40 cm FL (Figure 6, e) is detected, with an active and very marked migration towards the West, which arrives in less than two weeks towards 88-90°W and where it is dispersed (Figure 7, b). When the jack mackerel is lost at the West end, the fleet returns to the centered and very restricted area at 37°S / 78-79°W (Figure 7, b), to work on a jack mackerel with a different size structure from other months, of two main focused modes in 26-27 and 32-33 cm FL (Figure 6, e), that is, quite similar to that recorded in the catches of Chilean fleet in June 2017 inside the EEZ (Figure 6, b). This similarity of sizes in the catches of both fleets may indicate that in July the international fleet has operated in the migrating fish of the Chilean coasts towards the open ocean.

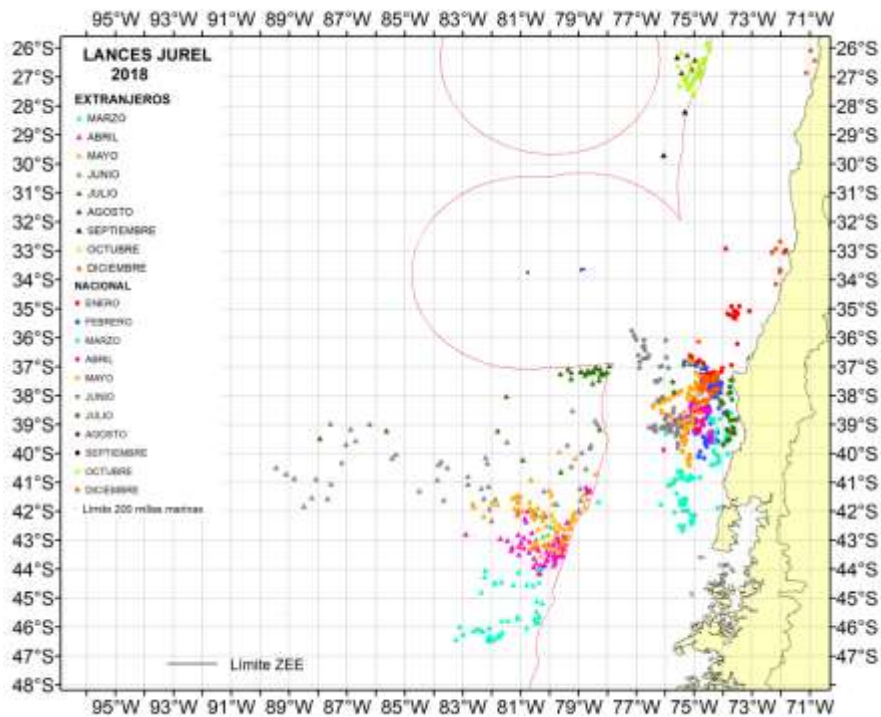
During the year 2019, the distribution and availability of jack mackerel for the international fleet presents a totally different picture of the years 2017-2018. The jack mackerel is detected from the end of February, with the distribution in the oceanic region away from the limit of the ZEE of Chile, between the months March-mid-June mainly from 82-83°W to 90-91°W and between 44-47°S (Figure 7, c)

This oceanic distribution is totally isolated, without detecting some connections with the jack mackerel concentrations distributed in the coastal areas of central-south Chile, which is very different from the previous years. This is also reflected in the size structure caught fish in that region, are larger in size, in a range of 36-54 cm FL, with the modes centered more towards 44-46 cm (Figure 6, f). The highest concentration of jack mackerel occurs during the month of April, then they have a very dispersed distribution that influences the decrease in fleet performance. During the month of July, as in July 2018, the fleet concentrates its operations in quadrant 37-38°S / 78-79°W, in the dispersed aggregations of migratory jack mackerel from coastal areas of Chile (Figure 7, c), in specimens of 28-44 cm FL, with modes of 32 and 36 cm (Figure 6, f).

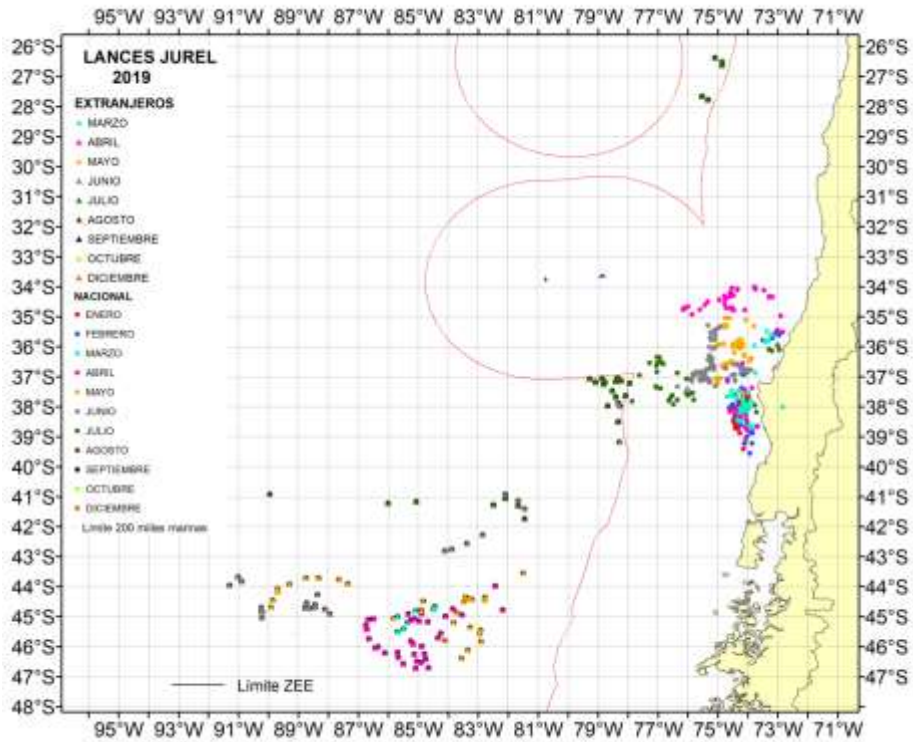
During the month of August 2019, as in the years 2014-2018, the international fleet moves its operations to the region “La Bota”, 24-27°S outside the Chilean EEZ, where jack mackerel fishing continues, mainly of small sizes, between 21-26 cm FL, of modal size of 23 cm (Figure 8).



a)



b)



c)

Figure 7. Monthly spatial distribution of fishing tows of jack mackerel of the central-south Chile fleet and international fleet during fishing seasons of the years 2017-2019.

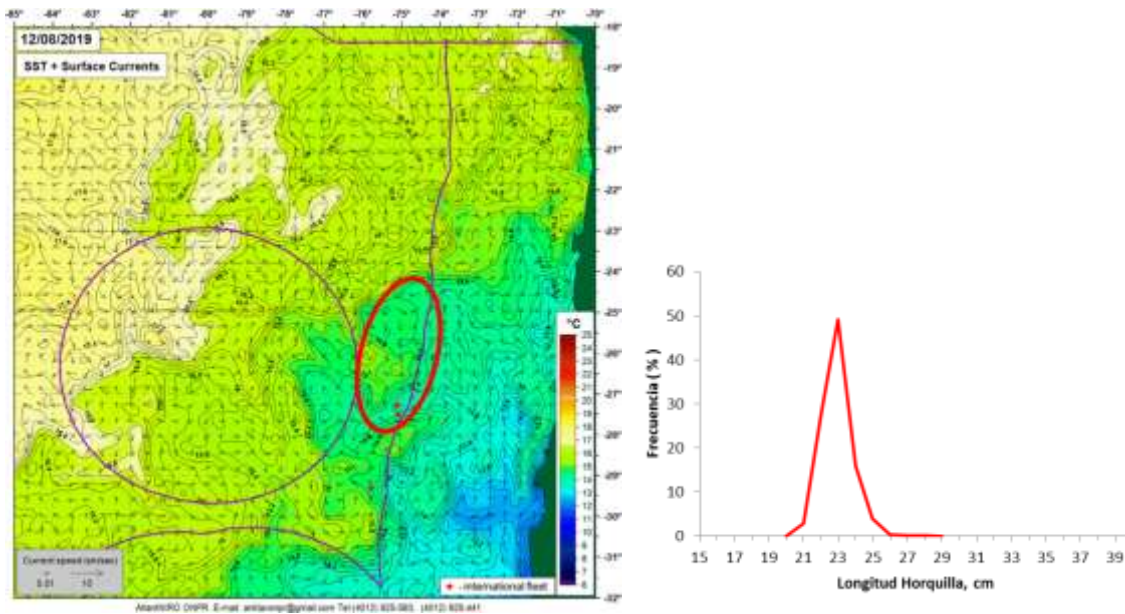


Figure 8. Fishing operations area of the international fleet and structure of jack mackerel sizes in catches during August 2019.

### 3. Discussion and conclusions

In general, in the region in front of south-central Chile from 2011-2012 there is a clear seasonality in the distribution, availability and commercial fishing of jack mackerel of Chilean fleet in coastal zones and international fleet in open ocean areas. Jack mackerel concentrations in front of the coast of central-south Chile (32-42°S approx.) presents from December to July-August, that is, from the moment of entry of spawning fish to the coast (December) until they leave to the oceanic spawning area (July-August)

In the oceanic region the jack mackerel resource is available for fishing in the form of fattening schools from the end of February-March in the areas located to the south 45-46°S between 87-83°W and the limit of the Chilean EEZ and, until the end of July-August when they move gradually fattening and maturing northward along the EEZ, up to approximately 37°S / 78°W, to subsequently migrate into Chilean waters within the insular EEZ of the Juan Fernández islands, also towards future oceanic spawning zone.

During this same period, there are also close links between the jack mackerel resource distributed in the coastal areas of Chile and present in oceanic waters adjacent to the limit of the EEZ of Chile. The information available in recent years of the monthly structures of jack mackerel sizes in coastal and oceanic catches indicates that the area of jack mackerel distribution in the oceanic zone is a continuation of it. Located in Chilean coastal waters and its western limit expands Westward no more than 83-84°W, only in a few months of some years up to 90-91°W, unlike the years 2002-2010 when fish concentrations were sighted westward of 100-120°W (Gretchina et al., 2018; Pastoors & Hintzen, 2018).

In this way it is assumed that the jack mackerel present in the oceanic region outside the EEZ is a part of migrating jack mackerel from the Chilean coasts during migrations to the fattening areas that occur frequently between the months of February to May of each year, the intensity of these migrations is dependent on the predominant oceanographic conditions in the region, mainly during the first three to four months from the date of approach to the coast post spawning jack mackerel (since December in general).

The other peculiarity in the structural dynamics of jack mackerel in front of the Chilean coast consists in that practically every year during the last 5-6 years towards the Chilean fishery, enter the powerful pulses of juvenile fish (<26 cm FL) of new recruitments. These fishes are first sighted by the international fleet in the oceanic zone of “La Bota”, outside the Chilean EEZ between 22-30°S, in the previous months (August-November) of the year when juveniles in variable abundance enter the Fishing operations areas of the Chilean fleet. In general, this coincides with the seasonal warming of waters and with the displacement of the Subtropical Front (with that the concentrations of juvenile jack mackerel are related) in NS and NW-SE directions, the process that occurs on average during the first two weeks of January and extends until March, even until April of each year. A high or low presence of juvenile jack mackerel in the fishery depends on the strength of the warm water pulses in the direction of the coasts and their deepening towards the south.



Jack mackerel is also characteristic of a spatial disaggregation of schools by size groups that is related to small fish distributed in warmer and more superficial waters, and larger fishes tend to be distributed in colder waters, as well as food availability and preference of each group of fish. For this reason, during the warm year (it can coincide with El Niño) the influence towards the coasts and towards the south of the region of warm waters can be stronger, with this, the entrances towards the coasts and the small fish migrations towards the south can be more abundant, forcing adult and larger fish to migrate to a greater extent south and south-west, towards the open sea

The strong entrance of warmer waters towards the coasts determines the most coastal distribution of the resource and more extended along the coast, this resource is also presented in greater abundance in the open sea and the fishing here is more stable practically during all season (March-August).

And vice versa, during the years with the oceanographic conditions in the areas near to coldest (relatively coldest) coasts, the distribution of juvenile fish may be further from the coast and not so deep to the south. Thus, in the proximity of the coast (in the case of central-south Chile, south of 36-37°S), areas with favorable conditions for distribution of larger size jack mackerel may be more stable over time, in these areas the accumulation of preferred prey (euphausiids) is due to the constant flows of productive subantarctic waters from the south along the coast. These conditions may be a factor that slows the migration (emigration) of adult jack mackerel to the south and to the open sea. In this last scenario, the fishery of the central-south Chile fleet is favored: there is a greater availability of the jack mackerel resource in areas quite close to the landing ports, in the fishing areas predominate large size fish. All this determines better quality of the products made in the process plants. However, less emigration to the south and towards the open sea in relatively colder conditions of the year may produce or produce a lower presence and / or temporary absence of jack mackerel in the open sea where is the international fleet operates.

As a consequence, in this region the distribution of jack mackerel is more dispersed and in wider areas, this determines the low yields of fishing by vessels and low catches accumulated during the fishing season for international fleet.

From the analysis, the distribution of the jack mackerel resource and the space-time dynamics of fishery in front of the coast of central-south Chile, both in the Chilean and international fleet during the years 2017-2019 (Figure 7), the visible differences in these parameters are established both in the coastal zone as oceanic between the years 2017 and 2018-2019, with a greater depth in the oceanic zone between 2017 and 2019. Similarly, there are significant differences in these periods in the dynamics of the predominant oceanographic conditions and associated with jack mackerel habitat, especially during the beginning of fishing seasons of this resource (December-March) (Figure 9).

The period of December 2016-March 2017 is possible to characterize as warm, it is reflected in the presence of ample areas of waters in front of the South American coasts with the positive SSTA (Figure 9, a). The fishing season of this year (2017) is characterized by the distribution of jack mackerel in Chilean waters quite wide latitudinal and coastal, with high presence of juvenile jack mackerel in the catches of the fleet and, with the



temporary stability and low variations in the structure of fish sizes in March-August outside the EEZ of Chile (Figures 6, a, d; 7, a).

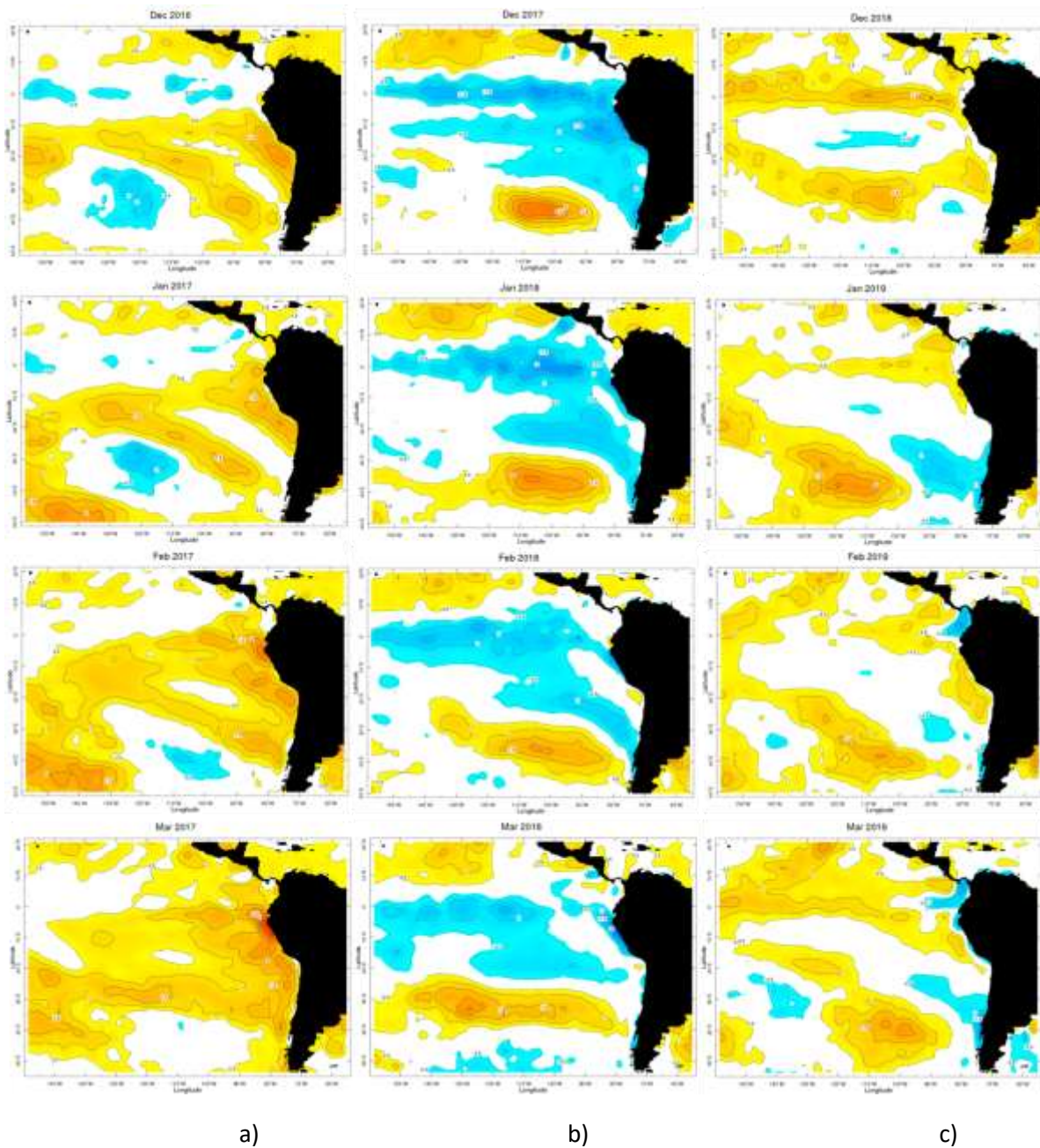


Figure 9. Monthly dynamics of sea surface temperature anomalies in the Southeast Pacific during the periods of December-March of the years 2016/2017, 2017/2018 and 2018/2019 ([http://iridl.ldeo.columbia.edu/maproom/ENSO/SST\\_Plots/Monthly\\_Anomaly.html](http://iridl.ldeo.columbia.edu/maproom/ENSO/SST_Plots/Monthly_Anomaly.html)).

The oceanographic conditions in the initial period of jack mackerel fishing season of 2018 (December 2017-March 2018, Figure 9, b) are totally opposite of the year 2017, can be characterized as the cold condition due to a large predominance against the coasts of Peru and Chile of waters with negative SSTA.

This may indicate a greater influence of cold sub-Antarctic waters of the south along the coast and with a detour to NW in front of the Chilean coast. This probably determined the concentrated distribution of adult jack mackerel in front of the coast of central-south Chile during the entire fishing season, the presence of small jack mackerel in the fishery was lower and only in the most remote areas of the coast (Figures 6 , b; 7, b).

However, despite the more oceanic distribution of small jack mackerel, the small jack mackerel still had an influence so that an important part of adult fish migrate to the open waters of the region and participate in the fishery of international fleet at least between March-May. In the relatively cold thermal conditions of 2018, also there have been significant migrations of adult jack mackerel in the direction of northern Chile (June-July) and even towards Peruvian waters (September-November).

During the start of the jack mackerel fishing season of 2019, the dynamics of oceanographic conditions in front of the Chilean coast are more complex (Figure 9, c). Thermal water conditions (based on SSTA) in front of the coast of central-south Chile fluctuate between neutral to negative and, further north of Chile and in front of the coast of Peru between neutral and positive. However, between November and December 2018 towards the coasts of central Chile, it has registered a powerful pulse of warm ocean waters perpendicular to the coast (Sepúlveda et al, 2019), passing just through the areas where historically (2012- 2018) records a high presence of juvenile fish

It is estimated that this thermal barrier could be a determining factor to juvenile jack mackerel concentrations practically do not migrate from the N-NW to the coastal waters of south-central Chile and, in their absence, massive jack mackerel migrations are not recorded adult towards the south by the coast and, especially, towards the open regional waters. As a result of the latter, the international fleet in March-June operates outside the Chilean EEZ exclusively on the “oceanic”, “resident” jack mackerel schools and only larger sizes

In this way, based on all this analysis, at least for the region in front of south-central Chile, there is an important role of oceanographic conditions in the jack mackerel habitat areas during the initial stage of resource entry (post-spawning fish) towards the regional fishery, determinants of different annual scenarios in the distribution, availability and success of this fishery both in the coastal areas and in the oceanic zone. The same oceanographic conditions, may be particular for each year, are determinants in the spatial distribution of juvenile fish: their greater presence and approach to regional coasts in the warm years causes more massive migrations of adult fish to the south by coast and, especially, towards the open sea and, on the contrary, during the relatively colder years the entrance of juvenile fish to fishery is less abundant and the emigrations of adult fish towards the south and the open sea are less intense. In addition, in the coldest years along the coast are formed quasi-stationary “lagoons” where there is an important accumulation of food for adult fish that, in the end, also favors greater concentration of fish and greater availability for fishing.

During the year 2019, in addition to these two factors (absence of juvenile jack mackerel and increased productivity and concentration of food (euphausiids)), determinants in the concentrated distribution and the close distribution to the coasts of central-southern Chile of jack mackerel resource. Also a third factor could be relevant: Almost total absence in the same areas of jumbo squid concentrations of sizes greater than 60-70 cm in mantle length

### **References:**

Gretchina, A., C. González & A. Sepúlveda. 2018. Spatio-temporal dynamics of the Chilean jack mackerel fishery in front of central-southern Chile, 2017-2018 period. SPRFMO, 6 th Meeting of the Scientific Committee Puerto Varas, Chile, 9 - 14 September 2018. SC6-JM02.

Gretchina, A. & A. Zúñiga, 2019 Particularidades en la distribución y pesca de calamar gigante frente las costas chilenas en la temporada de 2019 versus de 2017-2018. SPRFMO, 7 th Meeting of the Scientific Committee. Habana, Cuba, 7-12 October 2019.

Pastors, M.A. & N.T. Hintzen, 2018. Standardized Jack mackerel CPUE for the in front offshore fleet. SPRFMO, 6th Meeting of the Scientific Committee, Puerto Varas, Chili 9 - 14 September 2018.SC6-JM05.

Sepúlveda A., A. Gretchina, S. Núñez, S. Vásquez, P. González. 2019. Estimación de índices relativos de abundancia de huevos y larvas de jurel en el sector oceánico de Chile centro-sur durante el período de máxima actividad reproductiva. Pre-Informe Final, INPESCA-IFOP.