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Space-time variability of the Jack mackerel fishery 2020

Chile

Space-time variability of the Jack Mackerel fishery off central-south Chile in 2020 compared to 2017-2019

Carlos González & Aquiles Sepúlveda

Instituto de Investigación Pesquera (INPESCA), Talcahuano, Chile

Abstract

In 2020 (January-July) fishing activity on jack mackerel (*Trachurus murphyi*) mainly occurs within the coastal strip of 60 mn of the coast and were distributed between 29°40'S and 40°00'S, where 99% of the total industrial landings were landed. This was permitted by: (a) the high level of commercial aggregation presented by the near-coast jack mackerel shoals; (b) the high recurrence of shoal watching areas throughout this strip; c) the high abundance of shoals, largely caused by the presence of thermal gradient zones, high biological productivity sectors in retention zones caused by the presence of mesoscale eddies, and (d) further because these specimens captured this year largely met industry requirements (length and quality) for the production of by-products for human consumption. All this caused a low interest in the fleet to search for new fishing areas and attempt to expand its operation in the oceanic region, as recorded in previous years on the other hand when surveys were carried out in the ocean area for commercial and research purposes towards the end of autumn it did not yield successful results. It is noteworthy that the continuity of the fishing activity throughout 2020 in the coastal sector, which, while representing the highest point of a more coastal operating trend observed in recent years, breaks in part with the traditionally recorded space-time dynamics, in which commercial shoals were observed migrating to and outside the EEZ during June and July, which was registered in previous years by the national fleet and the international fleet. As long as the dynamics of the jack mackerel size structure indicated that in recent years there has been the entry of modal groups of 25 to 28 cm LH that have been present in the central-south sector as a second group of importance, migrating between the north and south center, as observed in 2020 with the modal group 27 cm FL, in which a North-South displacement was recorded in summer and then in autumn a return to the North. From January to May it was characterized by the presence of a bimodal structure with a group in 27 cm LH present from January to May and modal groups greater than 33 cm LH. And from June onwards by the presence of a modal group of 40 cm LH present throughout the range of the fishing operation. A low presence of low legal minimum size (BTML) specimens was highlighted which did not exceed 4% per month

It is relevant to continue monitoring the fishing operation in the coastal region and to establish whether this high concentration of the operation caused by a high availability of resource in this strip will be consistent in the coming years considering the quota regime to be delivered by the SPRFMO. Historically during the 1980s' the jack mackerel fisheries developed in a small area strongly associated with the coastal sector inland from 30 mn in front of the Eighth Region. It is likely that in the state of recovery apparently found in the jack mackerel population (moving from the contraction phase to the expansion phase), it will use different space-time structuring strategies that will allow it to increase its

expansion potential, as is to be strongly added in the coastal sector where biological productivity is higher than in the ocean region, as I would have done in the 1970s and part of the 1980s'.

1. General Background

For the past 20 years, the fishing operation of jack mackerel (*Trachurus murphyi*) has been defined by variable patterns in its spatial distribution, on the one hand there has been a strong expansion into the ocean region during the 2000s and on the other hand a concentration within the Exclusive Economic Zone (EEZ) for much of the 2010s, ending in 2020 in a mainly coastal distribution determined inland from the 60 mn strip of the coast.

Meanwhile, the international fleet has developed its jack mackerel fishing operation during the period 2013 to 2019 along the limit of Chile's EEZ, extending its area into the open ocean up to 82-84W, with extensions up to 90W in some months (Figure 1)

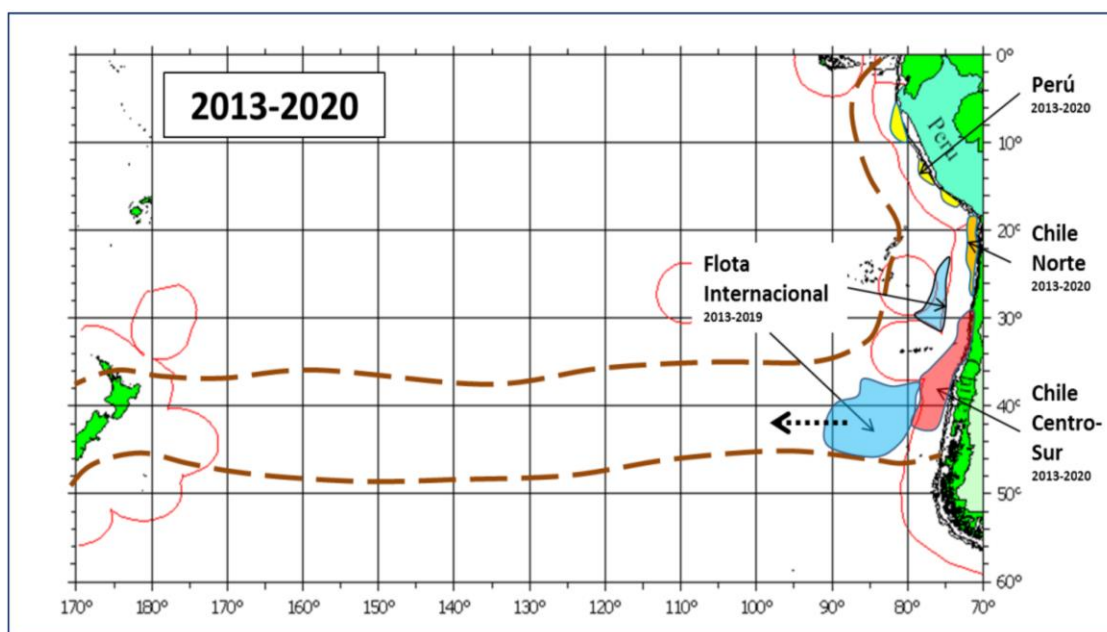


Figure 1. Outline of the main areas of fleet fishing operations on mackerel resource in the South Pacific between 2013-2020 (Adapted of Gretchina *et al.* 2019).

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

Generally the first commercial aggregations of jack mackerel are recorded by the fishing fleet of Central-South Chile, during the month of December. Much of these aggregations correspond to post-spawning adult individuals entering from the ocean region to develop their fattening stage in areas closer to the coast, which are characterized by high biological productivity. In addition, during this period the entry of subtropical waters from the north and northwest is generally observed, in which the registration of juvenile specimens of jack

mackerel that actively migrate from northern Chile to January or February along the coast has been recurrent. There have been years where this process has been more evident as in 2017, in which the fleet had to reduce its fishing operation due to the high presence of juvenile specimens, being reduced from February onwards.

From March-April, jack mackerel concentrations begin their migrations of fattening along the coast from the south to the north, this coincides with the beginning of seasonal empowerment of sub-Antarctic cold water flows from the SW-S. From July-August, mackerel migrations to the warmer ocean waters are activated, towards the N-NW of the region, in the direction of the oceanic areas of their future, where they disperse.

. In the open ocean, outside the EEZ of central-south Chile, where the international fleet operates and where the West 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 84-87W and south of 44-45S. From April-May the fleet is concentrated on the jack mackerel in the vicinity of the 200 nm line of the coast, in the migrating jack mackerel of the coastal waters of Chile, they gradually move from the south (43-44S) north along this line to encounter the border of the insular EEZ (Juan Fernández Islands) at 37S/78W towards the end of July-August (Gretchina *et al.* 2019). This exit route of jack mackerel (north-northwest by Chilean waters) of the area of the fishery is established from 2012-2013, is different from that recorded during the period 2002-2011, when the emigration of the resource had a well-defined route to the NW-W, to disperse in relief between 90-120W approximately in October-November (Pastoors & Hintzen, 2018). From this date the concentrations of jack mackerel enter within the EEZ and the international fleet leaves the southern region of its operations, moves north, towards the region of "La Bota" located between the continental and island EEZ (San Félix Islands and San Ambrosio), between approximately 24-30S. In this area the fleet operates mainly in small fish (17-28 cm FL), protrusions from the coast, between the months August-September – October-November (Gretchina *et al.* 2019).

Both annual cycles in the distribution of mackerel, reflected in the fishing operations of both fleets (coastal and high altitude), have been repeated with some modifications, between recent years, however, in 2020 mainly due to the presence of the pandemic by Covid-19 no high-altitude fishing operation was developed by the international fleet.

2. The fishery of Jack mackerel in 2020 versus 2017-2019

SPRFMO for Chile in 2017, 2018, 2019 and 2020 were allocated the annual global mackerel catch quotas at: 317,300 t, 371,887 t, 381,572 t and 439,034 t respectively and which, with transfers between countries in these years presented annual final values of: 351,521 t for the year 2017, 427,264 t for the year 2018, 443,137 t for 2019 and 523,514 t for 2020 (August). A higher percentage of these quotas in Chile are captured by Chile's central-south industrial fleet. In this region the fleet has captured in 2017 (January-December) 281,736 t, corresponding to 80.15%, in 2018 (January-December) 392,778 t, 91.93%, in 2019 (January-December) 401,452 t, corresponding to 90.6%, and 455,681 t, corresponding to 87.04% in 2020 (January-August) of the country's overall annual final share, considering transfers. The monthly dynamics of mackerel catches in south-central Chile for the period 2017-2020 are presented in Figure 2.

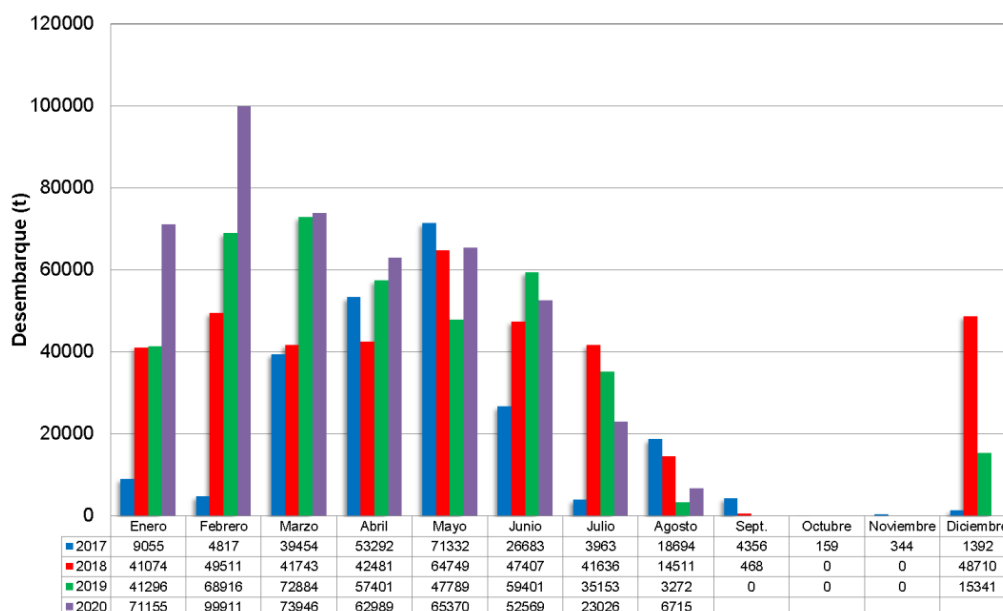


Figure 2. Monthly jack mackerel landings of Chile's central-south industrial fleet in 2017, 2018, 2019 and 2020 (until August) (Own elaboration, Source: Sernapesca)

Monthly mackerel landings in the central-south Chile region recorded between January and August 2020 (Figure 2) were clearly higher than the landings recorded for a similar period (January-August) in 2017 to 2019, with a magnitude of more than 115%, 36% and 17% in 2017, 2018 and 2019 respectively. It was highlighted in February 2020 with a maximum landing of close to 100,000 t, and secondly January and March in which the landings were above 70,000 t respectively landings that were higher than recorded in the other years analyzed. Subsequently, in the course of autumn and winter entry, landings were similar in behavior to those recorded in 2017-2019.

This incremental trend in industrial landings was also observed in the fishing yields of mackerel + jack mackerel from 2016 to 2020 (Figure 3). This may be an indicator of increased availability of mackerel for the fleet that allows each year to achieve greater catches with less fishing effort, determining in advance compliance with the annual fishing quota during the first 6-7 months of the year

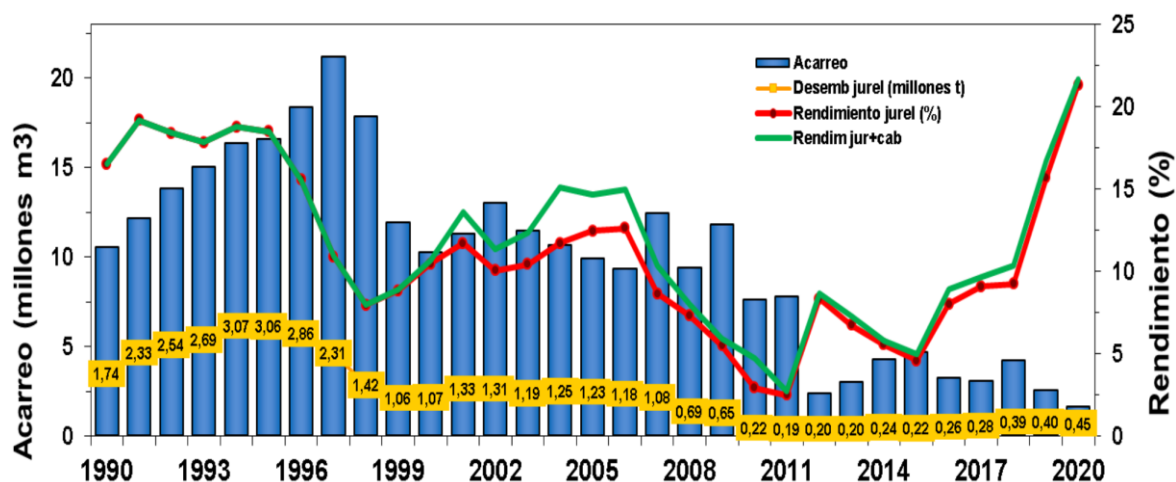


Figure 3. Annual dynamics of catches, hauling and yields of the industrial fleet of central south Chile that operates in the resources of jack mackerel and / or jack mackerel * mackerel between 1990-2019 (until august). The annual yields of jack mackerel and jack mackerel + mackerel are estimated by 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.

3. Dynamic space-time distribution and structure of jack mackerel sizes in 2020 versus 2017-2019

The 2020 jack mackerel fishing season off the coast of south-central Chile began in the early days of December 2019, by searching for and capturing jack mackerel in the coastal region located mainly within the 60 mn of the Eighth and Seventh Regions (35S-37S) (Figure 5). During the first quarter of 2020, the fleet maintained an operation within the coastal strip spread between 33.5S and 37S, with some brief forays westwards outside the 60 mn strip recorded during the month of January, it was noted that during this period the fleet landed 245,012 t of mackerel, corresponding to 54% of the landed until August 2020, indicating a high level of concentration and availability of jack mackerel shoals in this region, not observed in recent years.. In the second quarter the operation was divided into two sectors: (a) to the north it reached approximately 29.5S (Fourth Region); and b) to the south it was extended to 40S (Tenth Fourth Region), in this sector there was a high recurrence of fishing activity in the surroundings of Mocha Island during the months of June and July. This year he stood out for presenting a heavily concentrated fishing operation within the coastal strip of 60 mn of the coast, the factors that facilitated this situation were: (a) the high level of commercial aggregation and availability presented by the near-coast jack mackerel shoals; (b) the high recurrence of shoal watching areas throughout this strip; c) the high abundance of shoals, and (d) that these specimens captured this year largely met industry requirements for the production of by-products for human consumption in relation to size and quality. All this caused a low interest in the fleet to search for new fishing areas and try to expand its operation in the ocean region, as recorded in previous years. On the other hand, it is important to note that the few incursions made in autumn and winter into the oceanic region, at certain times, did not give favorable results for the fishing operation, something similar occurred in the acoustic prospecting of

mackerel carried out by the Institute for Fisheries Development (personal communication Head of the project, 2020), the search in the ocean region did not record the presence of relevant commercial shoals of jack mackerel in areas where this was common in previous years (personal communication Fleet Captains, 2020).

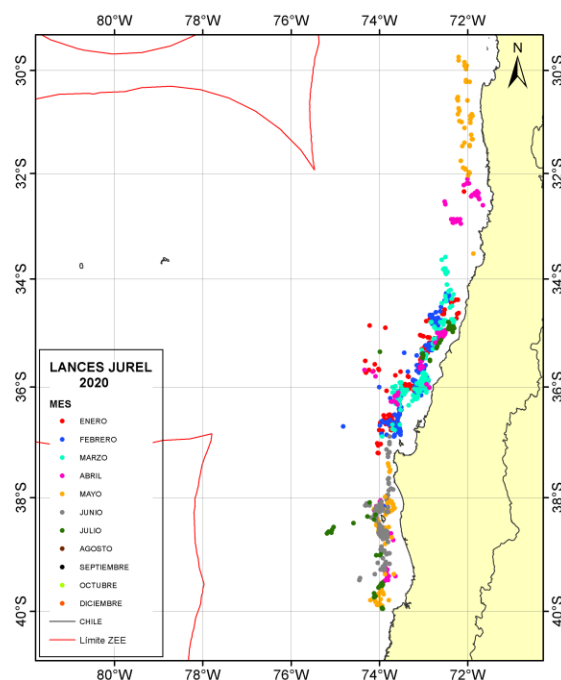


Figure 4. Spatial position of the jack mackerel fishing launches of the Chilean fleet between January-July 2020. (Own elaboration, Source: Inpesca).

This fishing operation during 2020 took place during the summer and early autumn mainly on the cold edges of thermal gradients along the coast, enhanced by coastal surge processes (Figure 5-A), and associated for the most part with the edge regions of high-concentration chlorophyll bulbs and in some cases in eddies edge regions of anticyclonic and cyclonic mesoscale (Figure 5-B). During the winter there was a further strengthening of the sub-Antarctic system, which caused a retreat of warm waters to the northwest region, and allowed a pre-term of waters with 12 and 13°C from 35°S to the South, however, the fishing operation continued to develop on the coastal strip, unlike in previous years, in which this dynamics of SST was associated with the displacement to the oceanic region of jack mackerel shoals.

In relation to the spatial distribution of the modal groups of jack mackerel (Figure 6) it could be noted that in January there was the presence mainly of modal length specimens 30 to 39 cm FL with presence of modal length specimens between 27 to 29 cm FL and a low presence of modal length specimens of 40 cm FL upwards, however, from February to May there was a progressive displacement of the modal group 26 to 29 cm FL to the north, a fact that was recorded because part of the fleet remained in its search and capture until this group left the south center area to the north registering a migration process. It should be noted that reports from the Institute for Fisheries Development (IFOP) for the summer and autumn period of 2020 have indicated the presence of this modal group in the fishery of the

First and Second Regions (Bohm, 2020), as well as records of the north jack mackerel cruiser carried out by this same institution, also recorded the presence of this modal group in the fourth region in 2020 (personal communication Project Manager, 2020). On the other hand, the modal group of 40 to 49 cm FL was present mostly in the area located south of 37°S during the fall, however, it is re-registered further north during the winter, in this case, west of the Seventh Region, as recorded in the summer.

On the other hand, the structure of jack mackerel sizes (Figure 7) for the year 2020, allowed to establish that from January to May was characterized by the presence of a bimodal structure with a group in 27 cm FL present from January to May and modal groups greater than 33 cm FL. And from June onwards by the presence of a modal group of 40 cm FL present throughout the range of the fleet. A low presence of low legal minimum size specimens was highlighted which did not exceed 4% per month

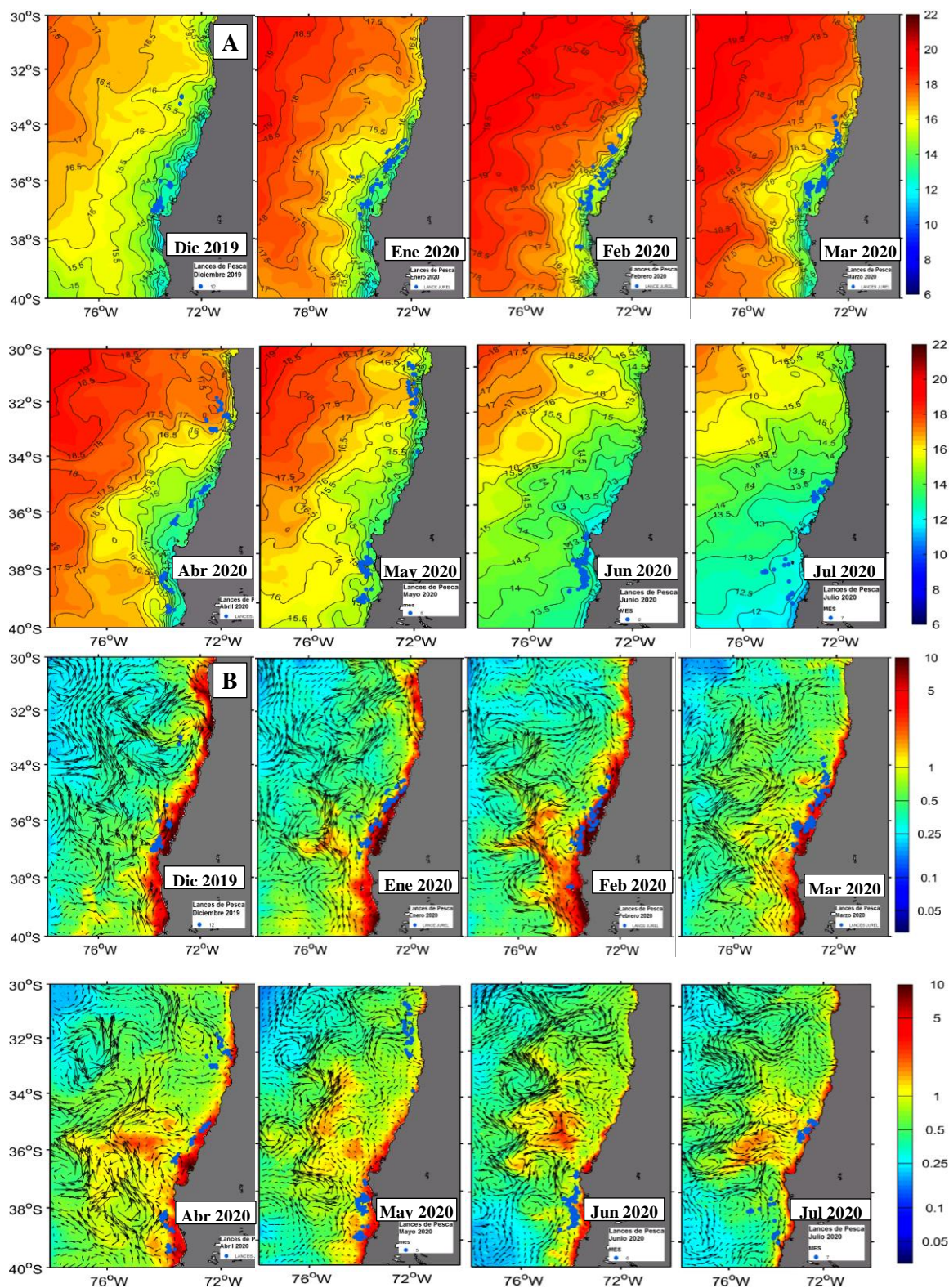


Figure 5. Spatial distribution of the Chilean fleet's jack mackerel fishing haul (blue dots), SST dynamics ($^{\circ}\text{C}$) (A) and chlorophyll dynamics (mg/m^3) + vectors of geostrophic currents (B) associated between December 2019 and July 2020. (Own elaboration, Source: Inpesca).

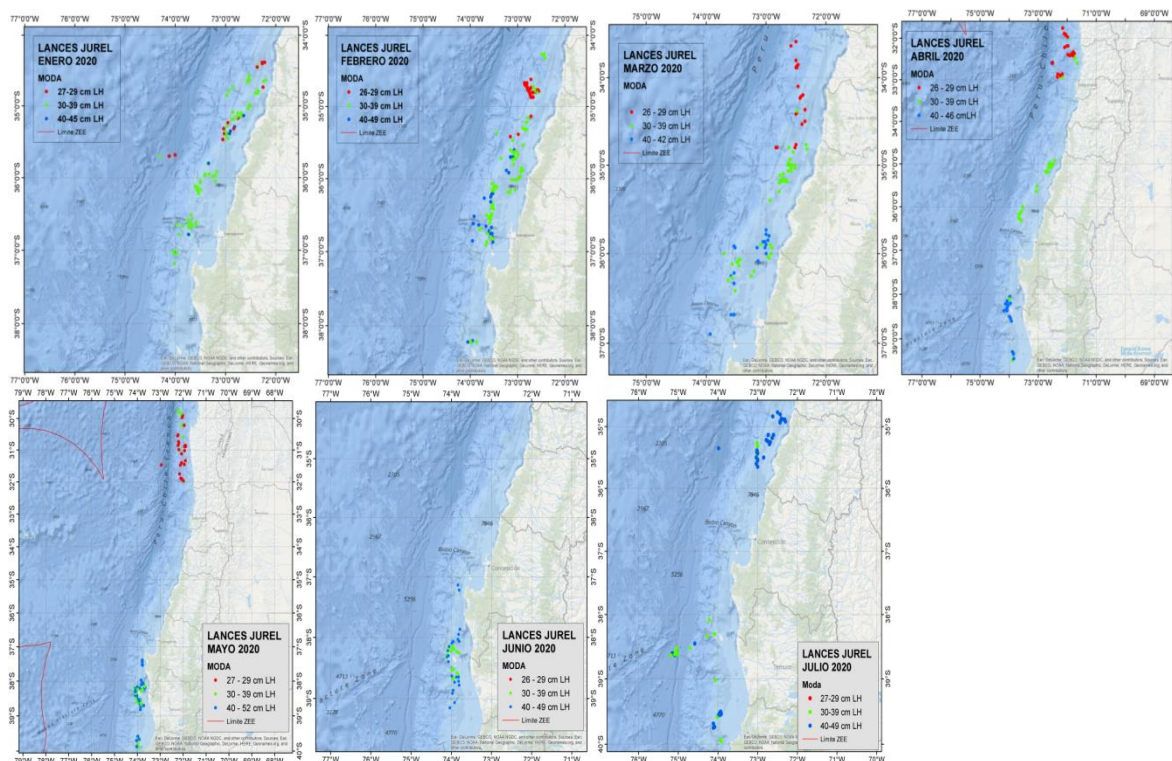


Figure 6. Spatial distribution of the modal groups (cm FL) of jack mackerel, recorded in the captures made by the industrial fleet in Central-South Chile, during the year 2020 (Own Elaboration: Inpesca Source).

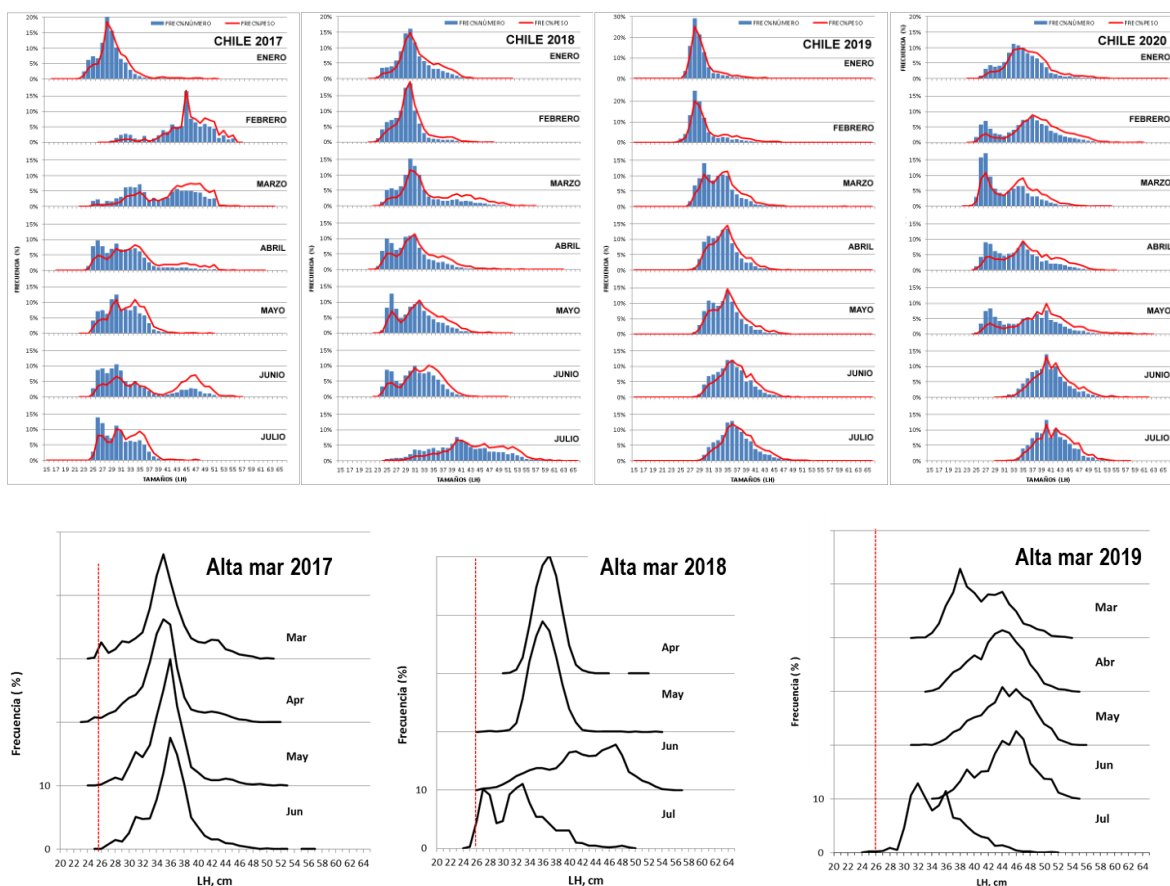


Figure 7. Structures of jack mackerel sizes in the catches of the Chilean fleet (Own elaboration, Source: Inpesca) and international (reported by the Russian and EU fleets) during the years 2017-2020

An analysis of the time-space dynamics of jack mackerel distribution in the 2020 fishing season (Figure 8) reiterates that fishing activity was persistently coastal (within the 60 mn mainly strip) throughout the year something that differed from what was observed in the period analyzed (2017-2020), where although coastal operation is observed, it is also possible to observe operation in the intermediate strip towards the EEZ boundary, in this regard it was observed that in June and July the fleet developed its fishing activity more closely towards the EEZ boundary, this because the captured shoals were initiating their migration to the ocean sector preparing for the period of spawning, despite this in July 2018, fishing operations were mainly recorded in the coastal area located within 60 mn between 37°S and 40°S

With regard to the size structure for the period 2017 to 2020 (Figure 7), it was possible to observe on a recurring basis the entrance to the area of the fish station of juvenile specimens during the summer period mainly from the north, which was recorded with the presence of a secondary modal size in 26, 25, 27, 28 cm FL in the period 2017 to 2019 and again 27 cm FL in 2020 in some years this secondary modal size remained in the monthly structure until winter and in others disappeared from the structure due to migration to other sectors, such as what happened during April 2020 (Figure 6), where the movement of

shoals to the north was observed. It was noted that during 2017 there was a significant entry of juvenile specimens under legal minimum size (>35% in number) which was perceived by the fleet in its operation, in this case the fishing company of the south-central region reacted by agreeing and implementing a good practice voluntarily that consisted of paralyzing much of the fleet during the months of January and February and conducting progressive surveys to establish whether the jack mackerel shoals had decreased the abundant presence of juvenile specimens, this determined a diminution in landings during these months (Figure 2) and also recorded during the month of February the presence of adult specimens with length greater than 40 cm FL (Figure 7) corresponding to "resident" shoals in the surroundings of Mocha Island.

In the ocean distribution of mackerel and in the operational dynamics of the international fleet outside the EEZ of central-south Chile in 2017-2020 there were also visible differences between the years, one of the main ones is that during 2020 there was no fishing operation in the Eastern South Pacific, largely due to the presence of the pandemic by Covid-19.

During 2017, between March and the beginning of August, jack mackerel fishing was concentrated exclusively along the EEZ boundary, not exceeding 83-84°W to the West, with a gradual shift north along it from 47°S in March to 37°S in July-August (Figure 8). During this period the structure of fish sizes in catches remained very stable, in a range between 26-46 cm FL, with modal size between 34-36 cm (Figure 7). It is assumed that the concentrations of jack mackerel captured by this year's international fleet corresponded to shoals present inside the EEZ that moved towards the oceanic region, and there was also no marked presence of juveniles that would allow to observe a secondary modal size as observed inside the EEZ of Chile.

During 2018, the same trend in jack mackerel distribution outside Chile's EEZ remained between March-May, i.e. with displacement along the 200 mn line of the coast in these months from 47-46°S to 42-41°S (Figure 8), presenting at the same time in catches similarity in the structure of fish sizes, with fluctuations between 32-42 cm FL, with modal groups of 35-37 cm FL (Figure 7). However, during the month of June, it is very likely that the concentrations of these fish have migrated into Chile's EEZ. During the same month, in conditions of almost total absence of fish near the Chilean EEZ, a mass of jack mackerel of larger sizes, about 40 cm FL (Figure 7), was detected in the area of approximately 40°S 80°W, with an active and very marked migration to the west, which arrived in less than two weeks towards 88-90°W and where it was subsequently dispersed (Figure 8). Losing the jack mackerel at the west end, the fleet returned to the focused and highly restricted area at 37°S/78-79°W (Figure 8), to work on jack mackerel of structure of different sizes from other months, of two main modal size focused on 26-27 and 32-33 cm FL during the month of July (Figure 7), that is, quite similar to that recorded in the catches of the Chilean fleet in June within the EEZ (Figure 7). This similarity of sizes in the catches of both fleets may indicate that in July the international fleet has operated on migrating fish from the Chilean coasts towards the open ocean (Gretchina *et al.* 2019).

During 2019, the distribution and availability of jack mackerel for the international fleet presented a completely different picture from the years 2017-2018. Jack mackerel was detected from the end of February, distributed in the oceanic region and away from the

limit of Chile's EEZ, between March-mid-June mainly from 82-83°W to 90-91°W and between 44-47°S (Figure 8). This oceanic distribution was completely isolated, without the detection of some connections with jack mackerel concentrations distributed in coastal areas of central-south Chile, which is very different from previous years. This was also reflected in the structure of fish sizes caught in that region, which were of larger sizes, in a range of 36-54 cm FL, with modal size centered more towards 44-46 cm FL (Figure 7). The highest concentration of the jack mackerel resource occurred during the month of April, subsequently they had a very dispersed distribution that influenced the decrease in fleet performance. During the month of July, as in July 2018, the fleet concentrated its operations in quadrant 37-38°S/78-79°W, on the scattered aggregations of migrating jack mackerel from coastal areas of Chile (Figure 8), in specimens of 28-44 cm FL, with modal size of 32 and 36 cm FL (Figure 7) (Gretchina *et al.* 2019).

During the month of August 2019, as in the years 2014-2018, the international fleet moved its operations to the region of "La Bota", about 24-27°S outside the EEZ of Chile, where jack mackerel fishing continued, mainly of small sizes, between 21-26 cm FL, modal size of 23 cm FL (Gretchina *et al.* 2019).

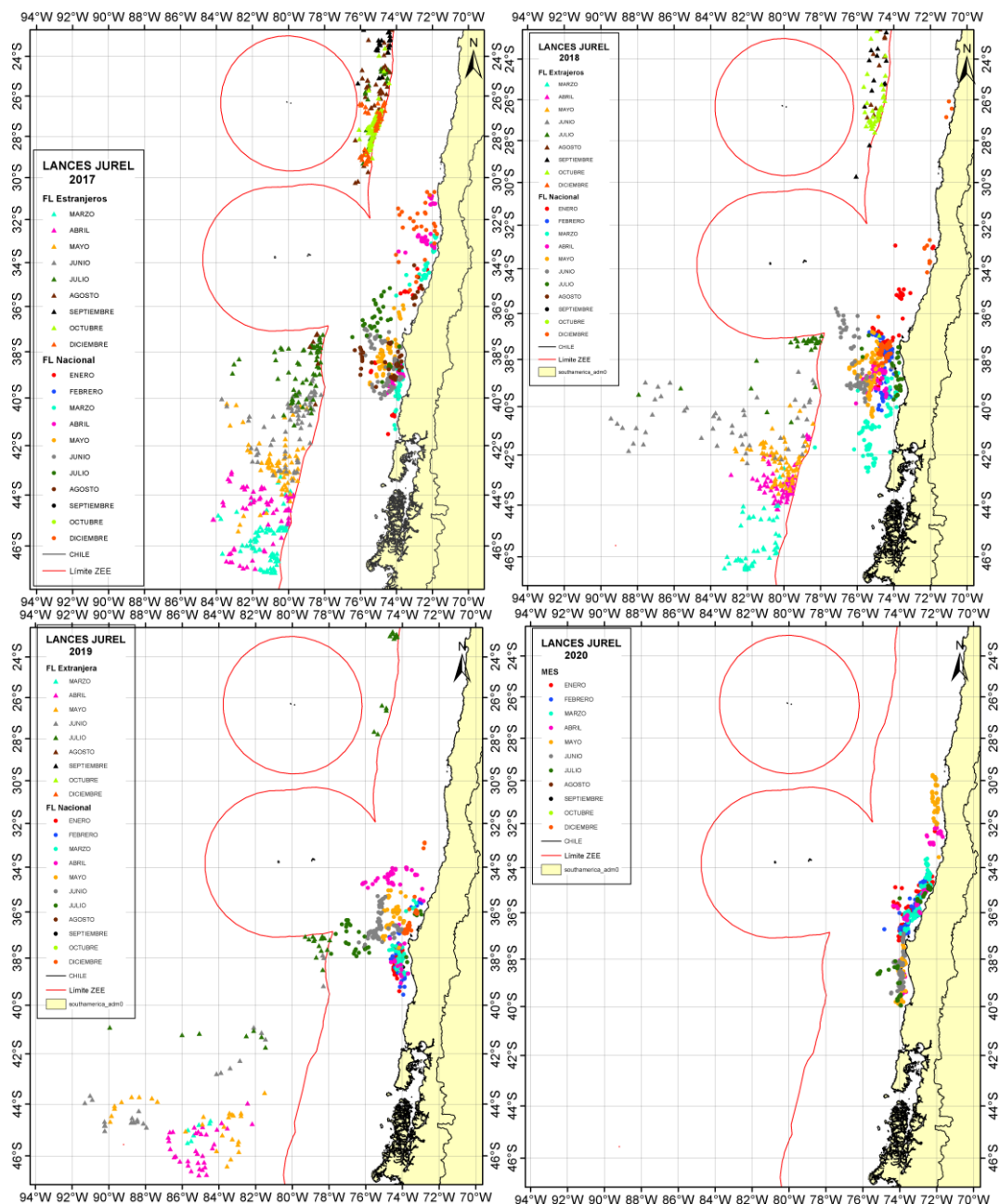


Figure 8. Monthly spatial distribution of jack mackerel fishing launches of the central-south and international Chile fleets during fishing seasons from 2017-2020. (Own elaboration, Source: Inpesca).

3.1. Spatial analysis of catches and size structure period 2017 to 2020.

In order to characterize the fishing operation within the 60 mn coastal strip of the coast and establish the impact it has represented in recent years on the fishing operation in jack mackerel in central-south Chile, a spatial analysis of the georeferenced catch data and size structures generated in the fishing operation of Chile's southern central fence fleet belonging to Inpesca was carried out. In this way, a mask was designed that allowed to extract the spatial data located inside the 60 mn strip of the coast and off it during the years 2017 to 2020 (Figure 9).

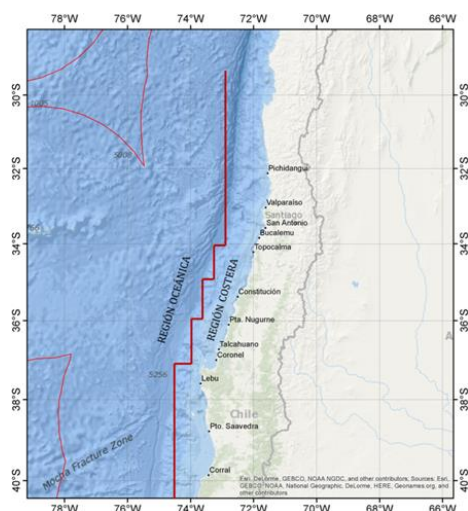


Figure 9. Representation of the limits used to differentiate the coastal region from the ocean, in the spatial analysis of the capture data 2017 to 2020 (Source: own elaboration).

The information generated made it possible to differentiate the operation into coastal and oceanic categories (Figure 10). It is important to note that the information Inpesca has received from its scientific observers and from captains and pilots who deliver information from their launch logs has accounted for a proportion of more than 30% of the total catches made by the fleet (Table 1). From this information, the fraction of the operation carried out inside and outside the coastal strip was estimated and subsequently determined the proportion that this strip has contributed in the total landing for each year analyzed (Figure 11). In this way, it was indicated that the coastal strip in this period of years analyzed has had an important participation, but also variable in the annual landing of jack mackerel, in this case in 2017 it was observed that 76% of the landing originated in this strip, decreasing to 24% the following year, however from this year until 2020 there was progressively an incremental trend that allowed to record in the last year that 99% of the landings were contributed from the coastal strip, this confirmed the comments made by fleet captains in interviews conducted by the team, in which they have indicated the presence of shoals in high concentrations in the coastal sector in previous years, as well as what was observed in 2020.

Table 1. Proportion as a percentage of the catch information used, relative to total jack mackerel catches for the period 2017 to 2020.

Proporción de la información de capturas utilizada.	2017	2018	2019	2020
	32%	38%	30%	40%

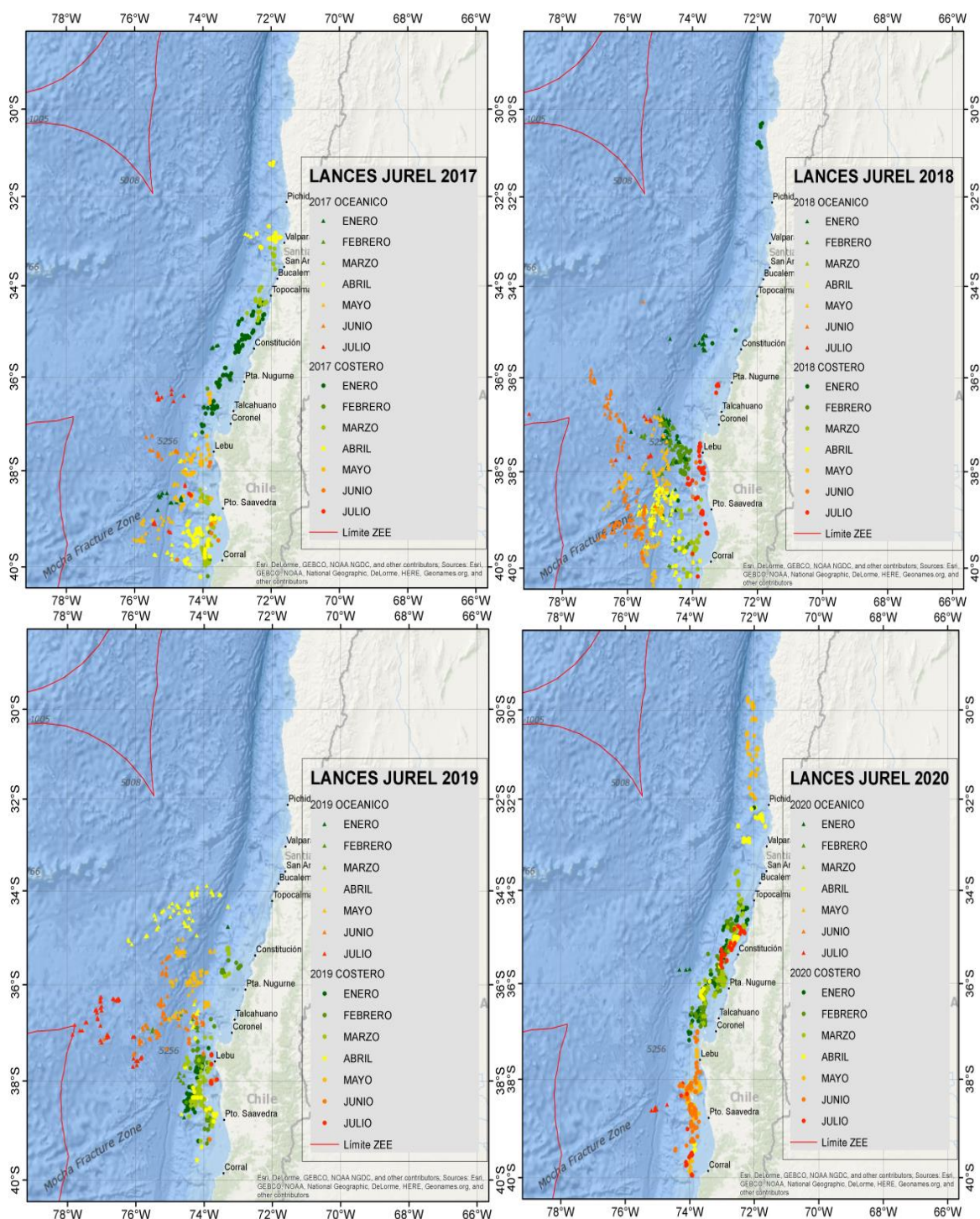


Figure 10. Spatial representation of jack mackerel fishing launches carried out inside and outside the coastal strip (triangles) from 2017 to 2020. (Own elaboration, Source: Inpesca).

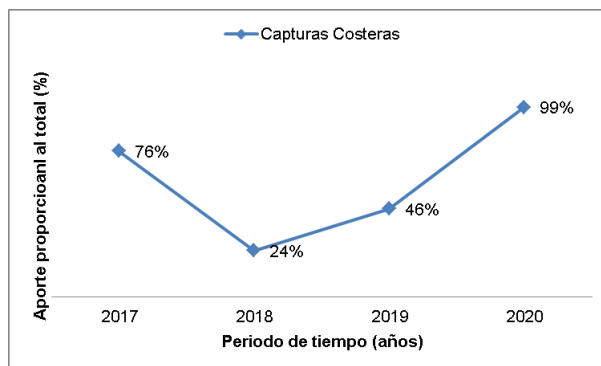


Figure 11. Contribution of coastal catches in percentage to the total landed in South-Central Chile during the years 2017 to 2020 (Source: Own elaboration).

With regard to the annual cumulative size structure (Figure 12) for the period 2017 to 2020 it was observed that within the coastal strip there was a higher range of sizes for the entire period analyzed than observed in the ocean sector, due to the presence of long-lived specimens called "coastal residents" (Gretchina *et al.* 2019) and adult and juvenile specimens that come from the ocean sector or the northern area and enter the region south central and remain in the fattening phase in this region, from mid-summer to winter, the latter groups represent the predominant fraction in annual landings. On the other hand, distribution in the ocean sector is more tight and stable (Figure 12 and 13), although there is similarity in the predominant groups in landings for most of the years analyzed, during 2019 this was not reflected, due to differences observed in the predominant groups, in this case, inside the coastal strip dominated the modal group of 28 cm FL and in the ocean sector the predominant modal group was the 35 cm FL (Figure 12). On the other hand, the entry of this 28 cm FL modal group in 2019 was highlighted, and in 2020 the entry of this group now with main fashion in 27 cm FL in a lower proportion than observed in 2019.

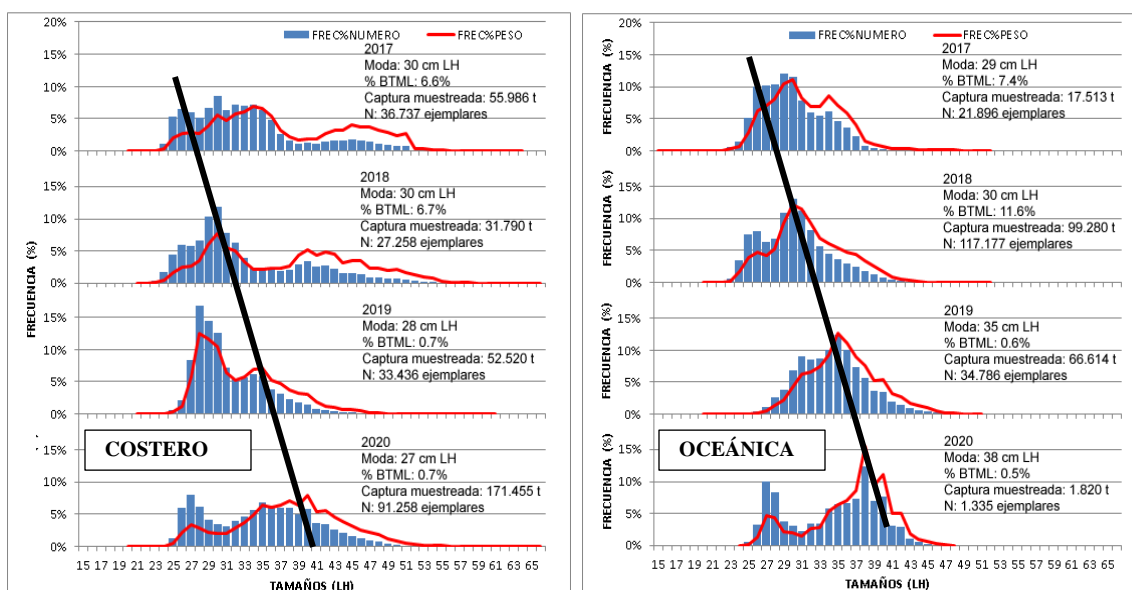


Figure 12. Structure of jack mackerel sizes accumulated annually in the catches of the Chilean fleet made inside and outside the coastal (coastal) strip, during the years 2017 to 2020 (Own elaboration, Source: Inpesca).

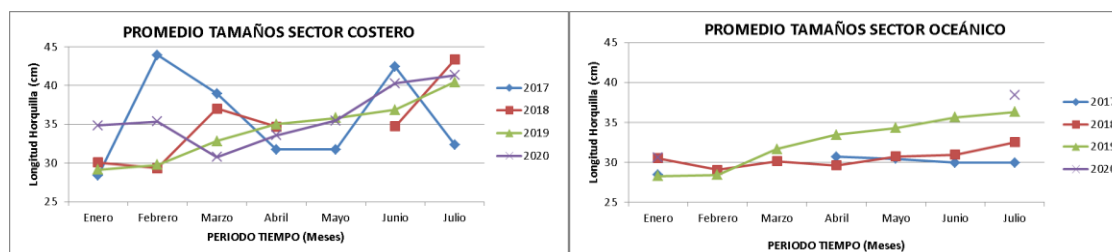


Figure 13. Average monthly sizes of jack mackerel obtained from within the coastal strip and in the ocean sector during the years 2017 to 2020 (Own elaboration, Source: Inpesca).

4. Discussion and conclusion

During 2020 the fishing operation in jack mackerel presented a strongly limited space-time dynamic within the coastal strip of approximately 60 mn of the coast. With a fleet similar to that deployed in the last 4 years, 450,000 t of jack mackerel was landed, this condition of greater aggregation of jack mackerel in this near-coastal strip was facilitated by the presence of thermal gradient zones, high productivity sectors and food accumulation in retention areas caused by the presence of mesoscale eddies, however, it is remarkable the continuity of this fishing activity throughout the year, which although it represents the highest point of a more coastal operating trend observed in recent years, breaks in part with the space-time dynamics traditionally recorded, as evidence of this, in the months of June and July there was almost no presence in the ocean sector (verified by the unsuccessful search for fleet vessels and by the 2020 mackerel acoustic cruiser). In previous years it was characteristic that in those months the displacement of fishing areas to the west and northwest was observed following the jack mackerel shoals that began their migration to the development phase, in this same sense, the foreign fleet recorded operation on jack mackerel shoals with structure of sizes similar to those captured inside the Chilean EEZ.

A particularity in the structural dynamics of jack mackerel off the Chilean coasts is that practically every year during the last 5-6 years towards Chilean fish have entered powerful pulses of juvenile fish (<26 cm FL), of new recruitments. These fish are first sighted by the international fleet in the oceanic zone of "La Bota", outside Chile's 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 seasonal warming of water and the displacement of the Subtropical Front (this relates to juvenile jack mackerel concentrations) in N-S 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 pulses of warm waters towards the coasts and their progress south (Gretchina *et al.* 2019). In this sense during these last years has been recorded the entry of modal groups of 25 to 28 cm FL that have been present in the central-south sector as a second group of importance, these have apparently been part of different groups that have been migrating between the north and south center, as observed in 2020 with the modal group 27 cm FL, in which there was a North-South displacement in summer and then in autumn a return to the north.

In this way, based on all this analysis, at least for the region versus Central-South Chile, an important role of oceanographic conditions in mackerel habitat areas during the initial stage

of entry of the resource (post-spawning fish) towards the regional fisheries is evident, determining different annual scenarios in the distribution, availability and success of fishing in both coastal and oceanic areas. The same oceanographic conditions, which may be particular for each year, are decisive in the spatial distribution of juvenile fish: their greater presence and approach to regional coasts in the warm years leads to more massive migrations of adult fish south along the coast and, especially, to the open sea and, conversely, during the relatively colder years the entry into the juvenile fish fish farm is less abundant and the migrations of adult fish southwards and open sea are less intense. In addition, in the colder years along the coast, quasi-stationary "lagoons" are formed where there is a significant accumulation of food for adult fish that, in the end, also favors a greater concentration of these and their greater availability for fishing (Gretchina *et al.* 2019)

Finally, it is relevant to continue monitoring the fishing operation in the coastal region and to establish whether this high concentration of the operation caused by a high availability of resource in this strip will be consistent in the coming years considering the quota regime to be delivered by the SPRFMO. It is important to note that historically during the 1980s' the jack mackerel fisheries developed in a small area strongly associated with the coastal sector within 30 mn versus the Eighth Region, it is likely that in the state of recovery apparently found in the jack mackerel population (moving from the contraction phase to the expansion phase), it will use different space-time structuring strategies that will allow it to increase its expansion potential, as is to be strongly added in the coastal sector where biological productivity is higher than in the ocean region , as I would have done in the 1970s and part of the 1980s'.

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