



Serial No. N7398

NAFO SCR Doc. 23/011

SCIENTIFIC COUNCIL MEETING – JUNE 2023

Analysis of the Flemish Cap cod fishery: monitoring of the consequences of the management decisions

by

Irene Garrido, Fernando González-Costas and Diana González-Troncoso

Instituto Español de Oceanografía, Vigo, Spain

Abstract

The objective of this document is to present the necessary information to the SC to monitor the consequences of the implementation in January 1st 2021 by the Commission of the technical measures in fisheries targeting cod in Div. 3M. The technical measures implemented were the closure of the cod directed fishery in Div. 3M in the first quarter of the year and the use of sorting grids in the cod directed trawl fishery. Data from the haul by haul database in the period 2016-2022 provided by the NAFO Secretariat have been used to study the situation before (2016-2020) and after (2021-2022) the measures were in place in the cod directed fisheries and in the fisheries with bycatch of cod. Also, the length and age distributions used in the assessment of this stock have been analysed.

It should be noted that, apart from the technical measures implemented since 2021, in the 2021-2022 period the TAC of 3M cod suffered a large reduction due to the stock situation. This large reduction in the TAC may make it difficult to interpret the changes observed in the fisheries after 2021, interfering in the interpretation of this analysis. In order to have a clear idea and describe appropriately the consequences of the implementation of technical measures, a longer series of data after implementation needs to be analysed.

Prior to 2021, most of the cod catches from the directed fisheries were taken in the first quarter and in the east and southwest of the bank for the longliners and in the southwest for the trawlers. Since 2021 catches are mainly taken in the second quarter and they are concentrated in the central part of Flemish Cap bank for the longliners and in the southwest of Flemish Cap for the trawlers. Almost 100% of the cod catches made with longline gear have been made in hauls targeting cod both before and after the technical measures were implemented. In the case of cod catches made in trawl hauls targeting cod that percentage dropped from over 96% in the 2016-2020 period to 85-88% in the 2021-2022 period. No significant change has been observed after the implementation of the technical measures in the catch composition and bycatch levels of the hauls directed to cod neither by longline nor trawl gears. In both directed fisheries, longliners and trawlers, the percentage of catches and effort inside the VME polygons in 2021-2022 is much lower than in 2016-2020.

The bycatch of cod in the longline hauls targeting other species is negligible in the whole period 2016-2022. Cod bycatch in trawl hauls targeting other species increased significantly after the technical measures were implemented, mainly in 2022. No major change has been observed in the spatial-temporal pattern of sets catching cod as bycatch before and after the implementation of the technical measures. The impact on vulnerable marine ecosystems of longline sets catching cod as bycatch is minimal in both periods. Regarding the trawl hauls catching



cod as bycatch, it should be noted the increase in effort carried out within the VME polygons of sponges and large gorgonians in the southwestern part of the Flemish Cap in 2022.

From the analysis of the total length and age distribution of the cod catches, it can be concluded that, after the implementation of the technical measures, in the longline the proportion of intermediate lengths (42-54 cm) and ages (4-5 years) has increased in the period of implementation of the technical measures, while the proportion of larger individuals (>99 cm) decreased. In trawling fishery, the proportions of smaller lengths (<45 cm) and the younger ages (1-3) have decreased after the implementation of the technical measures.

Introduction

In 2020 the Commission adopted technical measures, in force since January 2021 (NAFOa, 2021), to try to protect the productivity of Division 3M cod stock. These measures included the closure of the directed fishery of the 3M cod during the first quarter of the year, as well as the mandatory use of sorting grids in this fishery. The NAFO CEM establishes in its article 5 that *"close its directed fishery for cod in Division 3M between 00:00 UTC 1 January 2022 and 24:00 UTC 31 March 2022. During this period, all Contracting Parties shall ensure that its vessels limit the catches retained on board and in any one haul of this stock in line with Article 6.3(a) and observe the move-on provisions in Article 6.6(b)"* and in its article 13 that *"Each Contracting Party shall ensure that its trawl vessels conducting a directed fishery for cod in Division 3M, use a sorting grid for the purpose of reducing the catches of smaller individuals of cod. The minimum bar spacing of the sorting grid shall be 55 mm. The sorting grid must be placed in the top-side panel of the trawl preceding the codend"*.

To study the effects of these management measures, the Commission made a Request during September 2020 as: *The Commission requests Scientific Council, jointly with the Secretariat, to conduct ongoing analysis of the Flemish Cap cod fishery data by 2022 in order to:*

- a. *monitor the consequences of the management decisions (including the analysis of the redistribution of the fishing effort along the year and its potential effects on ecosystems, the variation of the cod catch composition in lengths/ages, and the bycatch levels of other fish species, benthos in general, and VME taxa in particular), and*
- b. *carry out any additional monitoring that would be required, including Div. 3M cod caught as bycatch in other fisheries during the closed period.*

The SC responded in 2021 (NAFOb, 2021) that as only one year of data with the new measures was available for this evaluation by June 2022, the analysis that SC would present in 2022 would have to be completed in subsequent years as the relevant dataset increases. The evaluation will compare the situation before and after the measures were in place, and will include analyses of, at least, the following aspects:

- Fishing pattern (e.g. spatial and temporal distribution of catch and effort).
- Impact of the fishing activity on VMEs.
- Length / age composition of the cod catch.
- Bycatch levels of 3M cod and distribution in other fisheries.
- Bycatch levels of other species in the 3M cod fishery.

The SC responded in 2022 (NAFO, 2022) that the analysis of the Flemish Cap cod fishery data was postponed until two years of logbook data are available following the implementation of the management measures, and proposed monitoring the consequences of management decisions every two years afterward, if required.

The aim of this document is to present the necessary information so that the SC can prepare the answer to Commission Request 11.

Material and Methods

Data from the haul by haul database provided by the NAFO Secretariat have been used to study the effort, catch and bycatch of the different fisheries that caught cod in NAFO Division 3M. As the haul by haul database is only fully available since 2016, data from 2016 to 2022 was used. From the haul by haul database, the hauls corresponding to Div. 3M with cod catches in the period 2016-2022 were selected. From this set of hauls, a debug similar to that made by Garrido *et al.* (2020a) was performed. Table 1 contains the logbook information analysed in this document. It contains the total number of hauls and the total catch of cod in the logbook information. The table also shows the data kept after the preliminary analysis. The number of hauls analysed are between 70% in 2021 and 99% in 2016, and the catches of cod analysed represent a percentage of the total that oscillates between 53% in 2021 and 99% in 2016 and 2020. As part of the data debug, trawl hauls with negative effort or greater than 24 hours have been removed. Removals of this type have had a great impact on the percentage of data analysed in 2021 due to the low number of total sets, while the number of sets discarded is similar every year, around 130.

It should be noted that apart from the technical measures implemented since 2021, in 2021 the TAC of Div. 3M cod suffered a large reduction due to the stock poor situation. This large reduction means that the percentages observed in 2021 present large differences with small variations in absolute quantities.

The entire analysis was made for the directed fisheries (trawl and longline) and for the non-directed fisheries catching cod as bycatch in NAFO Div. 3M. It is considered that a haul is targeting a particular species when, as defined in Article 5.2 of the NCEM, this species represents the highest percentage, in weight, in the total catch of the haul. The rest of the species that appear in the total catch composition of the haul are considered bycatch of the directed fishery.

The total length and age composition of the catches used as inputs in the stock assessment of 3M cod (Garrido *et al.*, 2023) were analysed before and after implementing the management measures to study the consequences of the implementation of those measures on the size and age composition of the catch.

In the NRA there are defined VME polygons from seven indicator species of Vulnerable Marine Ecosystems (VMEs): sponges, small gorgonians, large gorgonians, sea pens, black corals, bryozoans and boltenia. Both bryozoans and boltenia are not present in the Flemish Cap area (NAFO, 2020). The VMEs polygons are the ones that have been used to study the impact of the fishing activity on VMEs.

It is remarkable that no bycatch of benthos is registered in the analyzed logbook data, which means that the analysis of the bycatch of benthos in general, and VMEs in particular, cannot be addressed in this analysis with the logbook data.

Despite that, the position of the sets in the map reveals that some sets are conducted inside VME polygons. The analysis of the evolution of the effort in the VME polygons, if it increases or decreases since the technical measures are in force, may be considered as an indicator of the potential effects on vulnerable ecosystems of the redistribution of the effort due to the application of these technical measures.

Results

General analysis of the cod fisheries in 3M

Garrido *et al.* (2020b) described as follows the cod fisheries in the Flemish Cap: *There are two fisheries targeting cod that carry out more than the 90% of the annual total catches, the first with trawlers (around 65%) and the second with longliners (around 30%). There is another fishery (mainly redfish fishery) that catches cod as by-catch (around 5%). The main part of the annual total catches of cod in Div. 3M takes place in the first quarter (around 65%). Catches of the second (around 20%) and third quarters (around 10%) are considerably smaller and practically residual in the fourth quarter (around 5%).*

Table 2 shows the total catches of cod in Div. 3M of the analyzed data by year and gear, as well as the percentage carried out by each fishing gear by year. It can be observed that annual cod catches in Div. 3M have been quite

variable due to the state of the stock and have declined markedly in the last two years. These catches have been made with two different gears (trawl and longline) and the annual percentage that each gear represents to the total has also varied substantially in the period analyzed. The percentage of longline in the total catch in the 2016-2020 period has varied between 28-39%, with the exception of 2017 when it was only 8%. The longline percentage depends on Norway, that fishes one year with longliners and the next one with trawlers, although in both 2021 and 2022 it operated only with longliners. In the period 2021-2022, the level of catches has been quite low and the percentage of total catches made by the longliners (40-49%) has been higher than in previous years.

1.) Monitoring the cod target fisheries in Div. 3M

Catches and bycatch analysis.

Table 3 contains, by year and gear, the total catch in tons of cod in the area, as well as the catch of the hauls directed to cod in tons and in percentage of the total catch. This table shows that 3M cod is caught with two different gears: longline and trawl. Most of these catches are taken in directed fisheries. In the period 2016-2020 the percentage of directed cod catches over the total is greater than 96% while in the period 2021-2022 this percentage has dropped to 85-88%. Around 100% of the longline cod catches were obtained in hauls targeting cod in both periods. Regarding the trawl catches, in the 2016-2020 period the directed fishery has always represented, at least, the 94% over the total, while in the 2021-2022 period it dropped to around 75%.

Bycatch levels of other species in the 3M cod target fisheries.

Table 4 contains the composition of the catch in the cod directed longline fishery in 3M. In the longline directed hauls, cod represents between 96% of the catch in 2021 and 99% in 2016 to 2018. The level of bycatch of other species in the 2016-2020 period ranged from 3% to less than 1% of the total catch, while in the 2020-2021 period it was around 3%. The Atlantic halibut is the main bycatch of this fishery, representing less than 1% of the cod fishery catch in the 2016-2020 period and around 2.5% in the 2021-2022 period. So, it seems to be an increase in the level of bycatch in the last two years of the main species in the bycatch, the Atlantic halibut.

Table 5 presents the composition of the catch in the directed cod trawl hauls in Div. 3M. It can be observed that in the period 2016-2020, the percentage of bycatch varied between 4 and 9% and the main species caught as bycatch was redfish with percentages from 2 to 7%. In the 2021-2022 period, the bycatch percentage was between 7 and 10% and the main bycatch species was witch flounder (2%) in 2021 and redfish (8%) in 2022.

Fishing pattern (e.g. spatial and temporal distribution of catch and effort).

Figure 1 a and b show the maps with the distribution of hauls directed to cod by year and gear for the period 2016-2020 and 2021-2022. A decrease in the number of sets of longline and trawl fisheries targeting cod in the period 2021-2022, due to the decrease in the TAC, can be observed. This reduction has had the effect of concentrating sets in a much smaller area than in the 2016-2020 period, especially in the trawl fishery.

Table 6 shows the percentage of the annual cod catches and effort by quarter for directed Div. 3M cod fisheries for the period 2016-2022 based on the logbook information. The effort is measured in hours and number of hauls for the trawl fishery and in number of hauls for longline, since the duration of the sets is not an adequate measure of the effort for this gear and the number of hooks by haul is not available in the logbooks. Percentages are estimated relative to the total values (catch or effort) of the directed fishery by gear and year.

According to Table 6, in the period 2016-2020 the main part of the annual cod catches and effort in the directed fisheries in Div. 3M took place in the first quarter. Catches of the second and third quarters were considerably smaller and practically residual in the fourth quarter. In the period 2021-2022, after the reduction of catches and the implementation of technical measures, 100% of the longline effort and catches were made in the second quarter while in the trawl directed fishery the second quarter presented the highest percentage of catches and effort but significant percentages are observed in the fourth quarter in 2021 and in the third and fourth quarters in 2022.

Impact of the fishing activity on VMEs.

As commented before, the analysis of the evolution of the effort in the VME polygons may be considered as an indicator of the potential effects on vulnerable ecosystems. The analysis of the cod catches inside the VME polygons is also presented.

Table 7 contains, by year and gear, the catch of cod and effort (both in absolute numbers and percentage over the total of each year and gear) of hauls directed to cod that have been conducted inside the polygons of each VME indicator species. It must be noted that the hauls are inside the polygons, but outside the VMEs closed areas. Since some polygons are superposed and each haul is considered only once for the total, the total may not represent the sum of each VME indicator species. Figure 2 presents the percentage of cod catches and effort of the hauls directed to cod by year and gear made in the different polygons of each VME indicator and Figure 3 a and b shows the maps with the positions of the cod directed hauls by year and gear that have been made in the different VME polygons of Flemish Cap.

In the case of the directed fishery in the period 2016-2020, regarding the trawl fishery, the effort percentage (in hours) inside the VME polygons is between 12% in 2016 and 2019 and 21% in 2017 and 2020, almost all corresponding to the effort made in the large gorgonians VME polygon. This polygon, related with the closed area 13, coincides in part with the area of the southwest of the Flemish Cap in which Garrido *et al.* (2020b) located areas of large concentrations of spawning individuals during the first quarter of the year. The annual percentage of cod catches of this fishery within VME polygons is between 18% in 2019 and 36% in 2017. Most of these catches occur in the large gorgonians VME polygon. In 2017, more than 36% of the cod catches obtained in directed trawl hauls took place in VME polygons, almost 35% in large gorgonians VME polygon. In the case of the longline fishery, the percentages of effort (hauls number) observed vary between 5% in 2016 and 15% in 2018, being quite similar the annual percentage of cod catches within VME polygons, with percentages of 5% in 2016-2017, 7% in 2018-2019 and 9% in 2020. The percentages of catches and effort in the VME polygons are much lower than those observed in the trawl fishery. This lower percentage of catches and efforts in the VME polygons of the longline with respect to the trawl fishery is distributed among a larger number of VME indicator species. The sea pens and large gorgonians VME polygons are where most of the hauls are made and where the largest catches are obtained in the case of the longline fishery, except in 2017 where the catch percentages in the black corals VME polygon were higher.

Since the technical measures are in force, a sharp decline of effort and catches was observed inside the VME polygons for the directed fishery with both gears. In the case of the longline sets, it falls to 1% of catch and effort in 2022, being negligible in 2021. On the other hand, effort from the directed trawl fishery decreases to around 2% and catches to 4.6% in 2021, representing in 2022 around 0.5% of the total effort and catch.

2.) Monitoring the cod caught as bycatch in other fisheries in Div. 3M

Catches and bycatch analysis.

According to Table 3, almost 100% of the cod catches made with longline gear have been made in hauls targeting cod before and after the technical measures were implemented. Therefore, the analysis of cod bycatch in other fisheries will focus on trawl fisheries, although some information about the longline fisheries is shown. The bycatch of cod in trawl fisheries directed to species other than cod in the period 2016-2020 oscillates in percentage between 6% in 2020, and 3 % in 2017. This percentage of cod bycatch increased to around 15% per year in the period 2021-2022. In absolute numbers, this means that the catches of cod in Div. 3M made by other trawl fisheries in the analyzed data account for between 190 and 375 tons annually in the period 2016-2020 and 80 and 556 tons in 2021 and 2022 respectively.

Bycatch levels of cod 3M in fisheries targeting other species.

Table 8 shows the cod catches and effort of the trawl hauls targeting other species by year. The annual percentage of the different fisheries relative to the annual total cod caught as bycatch in other fisheries is also presented in this table and in Figure 4.

It can be observed that the trawl fishery that catches the highest percentage of cod as bycatch is the redfish fishery. In the period 2016-2020 the annual percentage is above 94% in all the years while in 2021 that

percentage is 55% and nearly 100% in 2022. The second fishery catching cod as bycatch is the witch flounder fishery with much lower percentages of around 4% during the period 2016-2020 and with a much higher percentage (45%) in 2021 and less than 1% in 2022.

It is important to highlight the large increase of the number of sets in 2022 in which cod was caught as bycatch. In that year more than twice hauls were observed with cod bycatch than the average number of sets observed in the 2016-2020 period. A similar effect can be observed in the cod catch as bycatch, with 555 tons caught in 2022, which is the double of the average observed in the 2016-2020 period (275 tons). This increase in the absolute level of cod bycatch and hauls in 2022 is not, in principle, related to an increase in the redfish TAC, since the 2022 redfish TAC was at a level very similar to that of 2018-2019, where cod catches as bycatch were 300 tons with a total number of sets of around 800, while in 2022 there were catches of 555 tons in more than 1 500 sets.

Fishing pattern.

Table 9 presents the annual cod catches and effort of the trawl hauls targeting other species by year and the catch and effort percentage by quarter relative to the annual total. Figure 5 shows the maps distribution of hauls catching cod as bycatch by year and fishery for the period 2016-2020 (a) and 2021-2022 (b).

In both periods, the sets of longlines with cod catches as bycatch are very few. In the trawl fisheries targeting other species, the quarters with the highest percentages of cod bycatch are the first and third quarters in both periods, except for the year 2021, where the highest percentage of catches were made in the second quarter of the year. Normally, the first and third quarters account for more than 90% of the cod bycatch and correspond to the quarters where most of the fishing effort directed to redfish is carried out.

Figure 5 does not show great changes in the spatial distribution of cod bycatch sets before and after the implementation of the technical measures, that more or less coincide with the spatial distribution of the redfish fishery. What can be seen in 2022 is a significant increase in cod bycatch sets in the southwest of Flemish Cap that was not observed in previous years.

Impact of the fishing activity on VMEs.

Table 10 shows, for the hauls catching cod as bycatch, the annual cod catch and effort and their proportion by gear, year and VME polygon for the period 2016-2022. As happens in the fisheries targeting cod, it is important to point out that the different polygons that delimit the VME of the different indicator species overlap in some cases, so the same haul information can appear in the estimates of several VME at the same time. Therefore, the total effort and catches do not have to coincide with the sum of the hauls of the different VMEs.

Figure 6 presents the percentage of the cod catch and effort (number of hauls), by year, gear and VME indicator, over the total of the hauls targeting other species with bycatch of cod. And Figure 7 shows the map with the positions of hauls made by other fisheries with bycatch of cod in the VME polygons for the period 2016-2020 (a) and 2021-2022 (b).

In the case of the longline fisheries with bycatch of cod in the period 2016-2020, it has already been commented that the annual cod bycatch is minimal. Of this minimal part, the percentages caught within the VME polygons is zero except in 2018 where 74% of that minimum catch was made within the large gorgonians VME polygon. In the period 2021-2022, there was no longliners cod bycatch within the VME polygons.

In the case of trawl fisheries targeting other species, the percentage of effort of the trawl hauls targeting other species with bycatch of cod in the VME polygons oscillates between 9% in 2016 and 18% in 2017, almost all corresponding to effort made inside the large gorgonians and sponges VME polygons in the period 2016-2020. In 2021-2022, this percentage increased, mainly in 2022 where 45% of the sets with cod bycatch were made within the large gorgonians and sponges VME polygons. This large increase in 2022 was mainly due to the increase in cod bycatch sets in the southwest area of Flemish Cap, which were not observed in the period 2016-2020, as can be seen in Figures 5 and 7.

Regarding the catches in the period 2016-2020, the annual percentage of cod bycatch within VME polygons is highly variable, between 8% in 2016 and 26% in 2018. Most of these annual percentages occur in the large

gorgonians and sponges VME polygons. In the period 2021-2022, this percentage was 12% in 2021 and 27% in 2022 and most of these annual percentages also occur in the large gorgonians and sponges VME polygons. It should be noted that in 2022 the percentage of cod bycatch caught within the sponges VME polygon (16%) was the highest observed in the period 2016-2022.

3.) Analyses of the cod catch composition in lengths and ages.

Two different gears are currently used in catching cod in Division 3M, trawl and longline. According to Table 2, most of the catch comes from trawlers. Longliners are used by Faroes (exclusively since 2017) and Norway every two years (even years), although in both 2021 and 2022 it operated only with longliners.

Trawl and longline catches length distributions for the total fishery (directed and bycatch) are available for several countries each year (not the same countries all the years), used for getting the total length distribution of the total catch of 3M cod (Garrido *et al.*, 2023). Figure 8 shows for the period 2016-2022 the cod catches length distribution in percentage by year for the longliners, trawlers and total catches. In this figure it can be seen that the 2016 length distribution is quite different from those observed later, especially for the trawl and total length distributions. Therefore, it was decided to use the periods 2017-2020 and 2021-2022 to compare the effects of the implementation of the technical measures. For this purpose, the average percentages by length observed in each period were calculated to obtain the average length distributions of the two periods (2017-2020 and 2021-2022) for the longliners, trawlers and total catches (Figure 9 and Table 11).

In Figure 9 and Table 11 it can be observed that the longline percentage length distributions before and after implementing the technical measures have changed, increasing the percentages of individuals caught between 42 and 54 cm from 8 to 21% and decreasing the individuals of more than 99 cm from 8 to 3%. In the case of the percentage length distributions of trawlers, these changes are less marked, although a decrease in the percentage of individuals caught below 42 cm (minimum landing size) and a general shift to slightly larger sizes are observed after the technical measures were implemented. The average percentage of individuals caught below the minimum landing size decreased from 3.5 to 0.4% after implementing the technical measures. The total length distribution of the two periods is more similar to the distribution observed in the trawlers, as expected due to their contribution to the total.

Figure 10 and Table 11 present the mean length observed in the cod catches of longliners, trawlers and total catches by year. A general decreasing trend can be observed in the longline mean length through the entire period 2017-2022, being by period lower after the implementation of the technical measures (2021-2022). In trawling the changes are not so clear, increasing in 2021 but returning to values similar to those observed in the 2017-2020 period in 2022. As with the length distributions, the mean length of the total catches closely resembles those observed in trawling due to the higher percentage of this gear in the total catches.

Figure 11 shows the age composition in percentage of the annual catches of longliners, trawlers and total for the period 2016-2022. These compositions by age are quite variable between the years for both the longline and the trawl and it is difficult to see any patterns in them, although it can be observed that in general the longline captures older individuals in higher percentages.

As in the case of lengths, it has been decided to present the average age composition of the longline, trawl and total catches for the period 2017-2020 and 2021-2022 (Figure 12 and Table 12). In the case of the longliners, the percentage of young ages (1-3 years) in the catches is similar before (2017-2020) and after (2021-2022) the implementation of the technical measures, 2.2 and 2.4% respectively. The intermediate ages (4-5 years) percentage increased considerably after implementing the technical measures from 10 to 31%, while for older ages decreased from 87 to 66%. The pattern in trawl catches is similar for intermediate and older ages; however, in this case a decrease in the percentage of young ages is observed after implementing the technical measures (2021-2022) from 4 to 0.3%. As expected, the pattern of total catches is more similar to that observed in trawl catches.

Conclusions

Trawl hauls with a negative effort or effort of more than 24 hours have been removed from this analysis. For future analysis of these technical measures, it may be convenient to measure the trawl effort using only the number of sets, as it occurs in the longline fishery. Thus, all the information removed due to errors in the

recording of the hauls time span (start and end of the haul) would be kept and used for the analysis (catch composition, location of the sets, number of sets, etc.).

It should be noted that, apart from the technical measures implemented since 2021 (the closure of the directed fishery of the 3M cod during the first quarter, as well as the mandatory use of sorting grids in the cod trawl directed fishery), in the 2021-2022 period the TAC of 3M cod suffered a large reduction due to the poor stock situation. This large reduction in the TAC may interfere in the interpretation of this analysis, erroneously attributing some of the observed changes in the fishery to the implementation of technical measures.

Also, the percentage of total catches made by the longlines (40-49%) in the period 2021-2022 was higher than in previous years (28-39%).

Cod directed fisheries in Div. 3M

Catches and bycatch analysis: Almost 100% of the cod catches made with longline gear have been made in hauls targeting cod before and after the technical measures were implemented. In the case of cod catches made in trawl hauls targeting cod that percentage dropped from over 96% in the 2016-2020 period to 85-88% in the 2021-2022 period. This drop may be largely due to the declining of the TAC in the 2021-2022 period rather than an effect of sorting grids or temporary closure.

Bycatch levels of other species in the 3M cod directed fisheries: No significant change has been observed after the implementation of the technical measures in the catch composition and bycatch levels of the hauls directed to cod neither by longline nor trawl gears.

Fishing pattern (e.g. spatial and temporal distribution of catch and effort): Prior to 2021, most of the cod catches from the directed fisheries were taken in the first quarter and in the east and southwest of the bank for the longliners and in the southwest for the trawlers. Since 2021 catches have been mainly taken in the second quarter and they are concentrated in the central part of Flemish Cap bank for the lonliners and in the southwest of Flemish Cap for the trawlers. What has been observed is that in 2021 and 2022 the sets are in a much smaller area in the south and center of Flemish Cap than in the 2016-2020 period, especially in the trawl fishery. This spatial concentration may be influenced by declining TACs in the 2021-2022 period rather than being exclusively the consequence of the implementation of sorting grids or temporary closure.

Impact of the fishing activity on VMEs: In both directed fisheries, longliners and trawlers, the percentage of catches and effort inside the VME polygons in 2021-2022 is much lower than in 2016-2020. This could mean that the conservation measures for 3M cod has a favorable impact in the conservation of the VMEs, although this conclusion could be not true due to the reduced effort in 2021-2022. More years of data would be needed to determine the impact of the conservation measures of the 3M cod on the VMEs indicators.

Cod caught as bycatch in other fisheries in Div. 3M

Catches and bycatch analysis: The bycatch of cod when operating with longline gears is negligible in the whole period 2016-2022. Cod bycatch in trawl hauls targeting other species increased significantly after the technical measures were implemented, mainly in 2022.

Bycatch levels of cod in other fisheries: The trawl fishery that catches the highest percentage of cod as bycatch is the redfish fishery, and the second is the witch flounder fishery with much lower percentages. It is remarkable the large increase of sets in 2022 in which cod was caught as bycatch. This increase in the absolute level of cod bycatch and hauls in 2022 is not, in principle, related to an increase in the redfish TAC since the 2022 redfish TAC was at a level very similar to that of 2018-2019 where cod bycatch was around 300 tons with a total number of sets of around 800, while in 2022 there were catches of 555 tons in a total of more than 1 500 sets.

Fishing pattern (e.g. spatial and temporal distribution of catch and effort): No major change has been observed in the spatial-temporal pattern of sets catching cod as bycatch before and after the implementation of the technical measures. In both periods, the sets of longlines targeting other species with cod catches as bycatch are very few. In the trawl fisheries targeting other species, the quarters with the highest percentages of cod bycatch are the first and third quarters in both periods. What has been observed is an increase in the number of cod bycatch sets in the southwestern part of the Flemish Cap in 2022.

Impact of the fishing activity on VMEs: The impact on VMEs of longline sets catching cod as bycatch is minimal in both periods. Regarding the trawl hauls catching cod as bycatch, it should be noted the increase in effort carried out within the large gorgonians and sponges VME polygons in the southwestern part of the Flemish Cap in 2022.

Analyses of the cod catch composition in lengths and ages.

From the analysis of the length and age distribution of the cod catches, it can be concluded that, after the implementation of the technical measures, in the longline the proportion of intermediate lengths (42-54 cm) and ages (4-5 years) has increased in the period of implementation of the technical measures, while the proportion of larger individuals (>99 cm) decreased. In trawling fishery the proportion of smaller sizes (<45 cm) and the younger ages (1-3) have decreased after the implementation of the technical measures. The reasons for the increase in the proportion of intermediate ages and lengths and the decrease in the larger lengths in the longliner catches may be partly related to variations in age abundances between periods and partly to the fact that, after the implementation of technical measures, the catches are no longer made in spawning concentrations as much as before. The decrease in the proportion of the small sizes in the trawl catches can be a consequence of the implementation of the sorting grids.

General conclusion.

In order to have a clear idea and describe appropriately the consequences of the implementation of technical measures, a longer series of data after implementation needs to be analysed.

Acknowledges

The authors would like to thank the NAFO Secretariat, and Tom Blasdale in particular, for providing the haul by haul data to carry out this study.

References

- Garrido, I., F. González-Costas and D. González-Troncoso, 2020 (a). Analysis of the NAFO VMS and logbook data. Serial No. N7144 NAFO SCR Doc. 20/068REV.
- Garrido, I., F. González-Costas, D. González-Troncoso, R. Alpoim and D. Garabana, 2020 (b). 3M cod possible technical measures: spatial / temporal closures. SCR Doc. 20/021. Serial No. N7067.
- Gonzalez-Costas, F., D. Gonzalez-Troncoso, A. Ávila de Melo and R. Alpoim, 2018. 3M cod assessment input data. SCR Doc. 18-001. Serial No. N6778.
- Kenchington, E., C. Lirette, F.J. Murillo, L. Beazley, A.-L. Downie. 2019. Vulnerable Marine Ecosystems in the NAFO Regulatory Area: Updated Kernel Density Analyses of Vulnerable Marine Ecosystem Indicators. Serial No. N7030 NAFO SCR Doc. 19/058.
- NAFO. 2020. Report of the 12th Meeting of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WG-ESA). Serial No N7027. NAFO Scientific Council Studies Document 19/25.
- NAFO, 2021a. Conservation and Enforcement Measures 2021. NAFO/COM Doc. 21-01. Serial No. N7153.
- NAFO, 2021b. Report of the Scientific Council Meeting 27 May -11 June 2021 By correspondence NAFO Halifax, Nova Scotia, Canada 2021. Serial No. N7205 NAFO SCS Doc. 21/14.
- NAFO, 2022. Report of the Scientific Council Meeting 03 -16 June 2022 Halifax, Nova Scotia, Canada 2022. Serial No. N7322 NAFO SCS Doc. 22/18.
- Garrido, I., D. González-Troncoso, F. González-Costas, 2023. Assessment of the Cod Stock in NAFO Division 3M. SCR Doc. 23/009. Serial No. N7396.

Tables

Table 1. Division 3M cod information from the original logbook (number of hauls, and cod catches) and the information used in the analyses after the debug process (number of hauls, and cod catches and their percentage relative to the original information).

	Total hauls (n)	Total Catch (t)	Kept hauls (n)	Kept Catch (t)	Kept hauls (%)	Kept Catch (%)
2016	1 901	11 193	1 883	11 141	99%	100%
2017	1 461	9 952	1 326	7 320	91%	74%
2018	2 595	10 526	2 486	9 717	96%	92%
2019	3 638	15 991	3 247	15 002	89%	94%
2020	1 314	7 684	1 291	7 619	98%	99%
2021	466	1 273	328	671	70%	53%
2022	2 069	3 937	1 911	3 712	92%	94%

Table 2. Division 3M cod catches (tons) by year and gear and their annual percentage by gear of the annual total cod catches of the logbook analyzed data.

	OTB	%	LL	%	Total
2016	7 500	67%	3 642	33%	11 141
2017	6 711	92%	608	8%	7 320
2018	6 431	66%	3 286	34%	9 717
2019	10 806	72%	4 196	28%	15 002
2020	4 648	61%	2 971	39%	7 619
2021	340	51%	331	49%	671
2022	2 243	60%	1 469	40%	3 712

Table 3. Division 3M cod total catches (tons), directed catches (tons) and bycatch (tons) by year and gear and the annual percentage of the directed catches relative to the annual total catches by year and gear of the logbook analyzed data.

	Gear	Total Catch (t)	Directed Catch (t)	Bycatch (t)	Directed Catch (%)
2016	LL	3 642	3 641	0	100%
2017		608	608	0	100%
2018		3 286	3 284	2	100%
2019		4 196	4 196	0	100%
2020		2 971	2 971	0	100%
2021		331	331	0	100%
2022		1 469	1 469	0	100%
2016	OTB	7 500	7 192	308	96%
2017		6 711	6 522	190	97%
2018		6 431	6 057	375	94%
2019		10 806	10 530	276	97%
2020		4 648	4 374	273	94%
2021		340	260	80	76%
2022		2 243	1 687	556	75%
2016	Total	11 141	10 833	308	97%
2017		7 320	7 130	190	97%
2018		9 717	9 340	377	96%
2019		15 002	14 726	276	98%
2020		7 619	7 345	273	96%
2021		671	590	80	88%
2022		3 712	3 156	556	85%

Table 4. Catch composition by species and year (total and percentage) and annual effort (number of hauls) of the longline cod directed hauls in Division 3M of the analyzed data.

		Species	Catch (t)	Catch (%)	Effort (n Hauls)
LL	2016	COD	3 641	99.3%	214
		HAL	20	0.6%	
		Others	7	0.2%	
	2017	COD	608	99.3%	30
		HAL	4	0.7%	
		Others	0	0.0%	
	2018	COD	3 284	99.5%	167
		HAL	11	0.3%	
		Others	7	0.2%	
	2019	COD	4 196	98.5%	239
		HAL	28	0.7%	
		Others	35	0.8%	
	2020	COD	2 971	97.3%	207
		HAL	27	0.9%	
		Others	56	1.8%	
	2021	COD	331	96.4%	17
		HAL	10	2.8%	
		Others	3	0.8%	
	2022	COD	1 469	97.2%	93
		HAL	29	1.9%	
		Others	14	0.9%	

Table 5. Catch composition by species and year (total and percentage) and annual effort (number of hauls and hours) of the trawl cod directed hauls in Division 3M of the analyzed data.

		Species	Catch (t)	Catch (%)	Effort (h)	Effort (n Hauls)
OTB	2016	COD	7 192	96.0%	4123	961
		RED	140	1.9%		
		PLA	70	0.9%		
		WIT	44	0.6%		
		HAL	25	0.3%		
		Others	20	0.3%		
	2017	COD	6 522	95.3%	3746	931
		RED	209	3.1%		
		PLA	48	0.7%		
		HAL	30	0.4%		
		WIT	16	0.2%		
		Others	18	0.3%		
	2018	COD	6 057	90.6%	5777	1423
		RED	440	6.6%		
		PLA	75	1.1%		
		HAL	52	0.8%		
		WIT	40	0.6%		
		Others	20	0.3%		
	2019	COD	10 530	94.1%	11142	2216
		RED	315	2.8%		
		PLA	170	1.5%		
HAL		92	0.8%			
WIT		43	0.4%			
Others		46	0.4%			
2020	COD	4 374	91.8%	3119	756	
	RED	196	4.1%			
	PLA	104	2.2%			
	WIT	44	0.9%			
	HAL	34	0.7%			
	Others	12	0.2%			
2021	COD	260	93.0%	223	51	
	WIT	6	2.1%			
	RED	5	1.9%			
	HAL	2	0.6%			
	PLA	1	0.5%			

		Others	6	2.0%		
	2022	COD	1 687	89.5%	1098	247
		RED	151	8.0%		
		HAL	5	0.3%		
		PLA	4	0.2%		
		WIT	2	0.1%		
		Others	36	1.9%		

Table 6. Division 3M cod percentage of catches and effort relative to annual catch and effort of the hauls targeting cod by year, gear and quarter.

	Quarter	LL				OTB							
		Y Catch	Q Catch (%)	Y Effort (n Hauls)	Q Effort (% n Hauls)	Y Catch	Q Catch (%)	Y Effort (h)	Q Effort (% h)	Y Effort (n Hauls)	Q Effort (% n Hauls)		
2016	1st		87%		77%				59%		28%		39%
	2nd	3 641	12%	214	15%	7 192	19%	4123	38%	961	33%		
	3rd		1%		9%		19%		28%		23%		
	4th				3%		7%		6%				
2017	1st				100%				100%				
	2nd	608		30		6 522	24%	3746	33%	931	32%		
	3rd				11%		21%		15%				
	4th				7%		8%		6%				
2018	1st				72%				61%				
	2nd	3 284	28%	167	40%	6 057	27%	5777	30%	1423	28%		
	3rd				16%		21%		19%				
	4th				13%		15%		17%				
2019	1st				59%				47%				
	2nd	4 196	14%	239	16%	10 530	32%	11142	27%	2216	27%		
	3rd				26%		36%		24%		20%		
	4th				1%		0%		29%		26%	27%	
2020	1st				54%				37%				
	2nd	2 971	42%	207	53%	4 374	21%	3119	18%	756	17%		
	3rd				4%		10%		17%		30%	24%	
	4th						5%		8%		7%		
2021	1st												
	2nd	331	100%	17	100%	260	63%	223	56%	51	69%		
	3rd						12%		5%		4%		
	4th						25%		40%		28%		
2022	1st												
	2nd	1 469	100%	93	100%	1 687	50%	1098	36%	247	43%		
	3rd						27%		33%		32%		
	4th						23%		32%		24%		

Table 7. Division 3M cod catch and effort (both in absolute numbers and percentage over the total of each year and gear) of hauls directed to cod in VME polygons, by year and gear.

	VME	LL				OTB					
		Catch (t)	Catch (%)	Effort (n Hauls)	Effort (% n Hauls)	Catch (t)	Catch (%)	Effort (h)	Effort (% h)	Effort (n Hauls)	Effort (% n Hauls)
2016	Black Corals	0	0.0%	0	0.0%	9	0.1%	5	0.1%	1	0.1%
	L. Gorgonians	91	2.5%	5	2.3%	1888	26.3%	381	9.2%	142	14.8%
	Sea Pens	101	2.8%	4	1.9%	5	0.1%	1	0.0%	1	0.1%
	S. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sponges	1	0.0%	1	0.5%	363	5.1%	94	2.3%	27	2.8%
	TOTAL	193	5.3%	10	4.7%	2264	31.5%	481	11.7%	171	17.8%
2017	Black Corals	22	3.7%	2	6.7%	5	0.1%	12	0.3%	2	0.2%
	L. Gorgonians	0	0.0%	0	0.0%	2262	34.7%	730	19.5%	222	23.9%
	Sea Pens	8	1.4%	1	3.3%	5	0.1%	6	0.2%	2	0.2%
	S. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sponges	0	0.0%	0	0.0%	61	0.9%	42	1.1%	11	1.2%
	TOTAL	31	5.0%	3	10.0%	2334	35.8%	789	21.1%	237	25.5%
2018	Black Corals	14	0.4%	1	0.6%	1	0.0%	2	0.0%	1	0.1%
	L. Gorgonians	86	2.6%	14	8.4%	1134	18.7%	744	12.9%	216	15.2%
	Sea Pens	147	4.5%	10	6.0%	2	0.0%	5	0.1%	1	0.1%
	S. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sponges	0	0.0%	0	0.0%	19	0.3%	14	0.2%	4	0.3%
	TOTAL	247	7.5%	25	15.0%	1155	19.1%	765	13.2%	222	15.6%
2019	Black Corals	46	1.1%	2	0.8%	1	0.0%	2	0.0%	1	0.1%
	L. Gorgonians	75	1.8%	4	1.7%	1828	17.4%	1229	11.0%	266	12.0%
	Sea Pens	160	3.8%	7	2.9%	0	0.0%	0	0.0%	0	0.0%
	S. Gorgonians	0	0.0%	0	0.0%	2	0.0%	9	0.1%	4	0.2%
	Sponges	24	0.6%	1	0.4%	52	0.5%	55	0.5%	12	0.5%
	TOTAL	305	7.3%	14	5.9%	1882	17.9%	1295	11.6%	283	12.8%
2020	Black Corals	111	3.8%	3	1.5%	0	0.0%	0	0.0%	0	0.0%
	L. Gorgonians	7	0.2%	3	1.5%	1216	27.8%	605	19.4%	163	21.6%
	Sea Pens	157	5.3%	9	4.4%	21	0.5%	12	0.4%	2	0.3%
	S. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sponges	0	0.0%	0	0.0%	71	1.6%	52	1.7%	10	1.3%
	TOTAL	275	9.3%	15	7.3%	1308	29.9%	669	21.5%	175	23.2%
2021	Black Corals	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	L. Gorgonians	0	0.0%	0	0.0%	12	4.6%	4	1.8%	1	2.0%
	Sea Pens	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	S. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sponges	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	TOTAL	0	0.0%	0	0.0%	12	4.6%	4	1.8%	1	2.0%

2022	Black Corals	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	L. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sea Pens	18	1.2%	1	1.1%	0	0.0%	0	0.0%	0	0.0%
	S. Gorgonians	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Sponges	0	0.0%	0	0.0%	5	0.3%	5	0.5%	1	0.4%
	TOTAL	18	1.2%	1	1.1%	5	0.3%	5	0.5%	1	0.4%

Table 8. Division 3M cod catches and effort of the trawl hauls targeting other species by year. The annual percentage of the different fisheries relative to the annual total cod caught as bycatch in other fisheries is also presented.

	Fishery	Catch(t)	Effort(h)	Effort (n Hauls)	Catch (%)
2016	RED	289	3 009	695	94%
	HAD	12	10	3	4%
	WIT	6	31	9	2%
2017	RED	185	1 543	345	98%
	WIT	5	24	9	2%
	HAL	0	7	1	0%
2018	RED	366	3 674	889	98%
	WIT	9	22	5	2%
2019	RED	275	3 964	784	100%
	WIT	1	18	5	0%
	HAL	0	19	3	0%
2020	RED	262	1 360	320	96%
	WIT	11	19	8	4%
2021	RED	45	1 047	243	55%
	WIT	36	31	17	45%
2022	RED	555	5 076	1 566	100%
	GHL	1	16	5	0%

Table 9. Division 3M cod catches and effort of the trawl hauls targeting other species by year and the catch and effort percentage by quarter relative to the total annual.

	Quarter	Bycatch (t)	Bycatch (%)	Effort (h)	Effort (%h)	Effort (n Hauls)	Effort (% n Hauls)
2016	1st	308	43%	3 050	48%	707	52%
	2nd		2%		1%		1%
	3rd		55%		51%		47%
	4th		0%		0%		0%
2017	1st	190	47%	1 575	44%	355	47%
	2nd		1%		2%		3%
	3rd		52%		54%		50%
	4th						
2018	1st	375	68%	3 696	41%	894	41%
	2nd		2%		1%		1%
	3rd		30%		58%		59%
	4th						
2019	1st	276	57%	4 001	23%	792	30%
	2nd		5%		2%		3%
	3rd		38%		75%		66%
	4th						
2020	1st	273	59%	1 379	41%	328	48%
	2nd		4%		1%		2%
	3rd		37%		57%		49%
	4th		0%		1%		1%
2021	1st	80	32%	1 078	44%	260	54%
	2nd		45%		3%		7%
	3rd		24%		53%		40%
	4th						
2022	1st	556	32%	5 092	52%	1571	60%
	2nd						
	3rd		68%		47%		39%
	4th		1%		1%		1%

Table 10. Division 3M cod bycatch and effort (both in absolute numbers and percentage over the total of each year and gear) of hauls directed to other species in VME polygons, by year and gear.

	VME	LL				OTB					
		Catch (t)	Catch (%)	Effort (n Hauls)	Effort (% n Hauls)	Catch (t)	Catch (%)	Effort (h)	Effort (%h)	Effort (n Hauls)	Effort (% n Hauls)
2016	Black Corals	0	0%	0	0	1	0%	0	0%	1	0%
	Large Gorgonians	0	0%	0	0	18	6%	13	0%	6	1%
	Sea Pens	0	0%	0	0	0	0%	26	1%	5	1%
	Small Gorgonians	0	0%	0	0	5	2%	203	7%	43	6%
	Sponges	0	0%	0	0	2	1%	34	1%	9	1%
	TOTAL	0	0%	0	0	26	8%	277	9%	64	9%
2017	Black Corals	0	0%	0	0	0	0%	0	0%	0	0%
	Large Gorgonians	0	0%	0	0	8	4%	88	6%	19	5%
	Sea Pens	0	0%	0	0	1	0%	14	1%	3	1%
	Small Gorgonians	0	0%	0	0	9	5%	128	8%	28	8%
	Sponges	0	0%	0	0	21	11%	52	3%	13	4%
	TOTAL	0	0%	0	0	39	21%	282	18%	63	18%
2018	Black Corals	0	0%	0	0	0	0%	1	0%	1	0%
	Large Gorgonians	1	74%	1	50	89	24%	409	11%	114	13%
	Sea Pens	0	0%	0	0	0	0%	3	0%	1	0%
	Small Gorgonians	0	0%	0	0	5	1%	76	2%	17	2%
	Sponges	0	0%	0	0	5	1%	105	3%	22	2%
	TOTAL	1	74%	1	50	99	26%	593	16%	155	17%
2019	Black Corals	0	0%	0	0	1	0%	34	1%	7	1%
	Large Gorgonians	0	0%	0	0	36	13%	164	4%	40	5%
	Sea Pens	0	0%	0	0	0	0%	9	0%	2	0%
	Small Gorgonians	0	0%	0	0	1	0%	17	0%	7	1%
	Sponges	0	0%	0	0	23	8%	255	6%	56	7%
	TOTAL	0	0%	0	0	61	22%	478	12%	112	14%
2020	Black Corals	0	0%	0	0	2	1%	35	3%	6	2%
	Large Gorgonians	0	0%	0	0	26	9%	98	7%	30	9%
	Sea Pens	0	0%	0	0	0	0%	0	0%	0	0%
	Small Gorgonians	0	0%	0	0	1	0%	9	1%	3	1%
	Sponges	0	0%	0	0	8	3%	46	3%	12	4%
	TOTAL	0	0%	0	0	37	13%	188	14%	51	16%
2021	Black Corals	0	0%	0	0	0	1%	6	1%	1	0%
	Large Gorgonians	0	0%	0	0	7	8%	95	9%	26	10%
	Sea Pens	0	0%	0	0	0	0%	5	0%	1	0%
	Small Gorgonians	0	0%	0	0	1	1%	11	1%	3	1%
	Sponges	0	0%	0	0	2	3%	46	4%	13	5%
	TOTAL	0	0%	0	0	10	12%	163	15%	44	17%
2022	Black Corals	0	0%	0	0	3	1%	49	1%	17	1%

Large Gorgonians	0	0%	0	0	56	10%	771	15%	342	22%
Sea Pens	0	0%	0	0	2	0%	5	0%	1	0%
Small Gorgonians	0	0%	0	0	2	0%	54	1%	18	1%
Sponges	0	0%	0	0	87	16%	940	18%	334	21%
TOTAL	0	0%	0	0	150	27%	1819	36%	712	45%

Table 11. Division 3M cod mean length distribution in percentage by gear and total for the period 2017-2020 and 2021-2022 in the directed 3M cod fishery.

Length (cm)	Abundance (2017-2020) (%)			Abundance (2021-2022) (%)		
	OTB	LL	TOTAL	OTB	LL	TOTAL
18	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0
27	0.1	0.0	0.1	0.0	0.0	0.0
30	0.2	0.0	0.2	0.0	0.1	0.0
33	0.2	0.1	0.2	0.0	0.1	0.0
36	0.4	0.4	0.5	0.0	0.1	0.0
39	1.0	0.7	1.0	0.1	0.6	0.3
42	1.4	0.8	1.3	0.3	1.8	1.1
45	2.5	1.7	2.4	1.1	4.2	2.6
48	4.1	1.3	3.6	5.2	6.2	6.0
51	5.9	1.9	5.1	7.3	5.0	6.6
54	8.4	2.9	7.4	7.7	3.8	6.5
57	11.8	4.9	10.4	7.3	3.5	6.0
60	14.4	7.6	13.1	9.9	6.3	8.5
63	13.8	9.8	13.0	11.8	6.7	9.7
66	11.3	9.5	10.9	14.6	6.7	11.2
69	9.0	11.1	9.4	10.4	10.5	10.0
72	6.2	9.2	6.9	8.2	8.9	8.0
75	4.2	6.8	4.7	5.5	7.5	6.1
78	2.1	6.5	3.1	3.9	6.4	4.7
81	1.1	4.2	1.7	2.1	6.1	3.5
84	0.5	3.7	1.1	1.9	4.4	2.9
87	0.4	2.9	0.9	1.1	3.0	1.8
90	0.3	2.4	0.7	1.0	2.5	1.6
93	0.1	1.7	0.4	0.3	1.4	0.8
96	0.1	1.7	0.4	0.1	1.4	0.6
99	0.0	2.0	0.4	0.1	0.9	0.4
102	0.0	1.3	0.3	0.0	0.5	0.2
105	0.0	1.0	0.2	0.1	0.4	0.2
108	0.0	1.3	0.2	0.0	0.3	0.1
111	0.0	0.8	0.1	0.0	0.2	0.1
114	0.0	0.7	0.1	0.0	0.2	0.1
117	0.0	0.5	0.1	0.0	0.2	0.1
120	0.0	0.2	0.0	0.0	0.1	0.1
123	0.0	0.1	0.0	0.0	0.1	0.1
126	0.1	0.1	0.1	0.0	0.1	0.0
129	0.0	0.0	0.0	0.0	0.0	0.0
132	0.0	0.0	0.0	0.0	0.0	0.0

135	0.0	0.0	0.0	0.0	0.0	0.0
138	0.0	0.0	0.0	0.0	0.0	0.0
Mean length	61.2	72.2	63.4	64.2	68.5	65.6

Table 12. Division 3M cod mean age distribution in percentage by gear and total for the period 2017-2020 and 2021-2022 in the directed 3M cod fishery.

Age	Abundance (2017-2020) (%)			Abundance (2021-2022) (%)		
	OTB	LL	TOTAL	OTB	LL	TOTAL
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.6	0.2	0.5	0.0	0.1	0.1
3	3.2	2.3	3.1	0.3	2.1	1.2
4	9.4	3.6	8.2	17.2	16.6	18.0
5	17.5	6.8	15.3	25.4	14.9	21.3
6	28.5	17.3	26.6	20.5	14.8	18.2
7	21.5	20.2	21.3	11.1	9.4	10.0
8	19.2	49.7	25.0	25.5	42.1	31.2

Figures

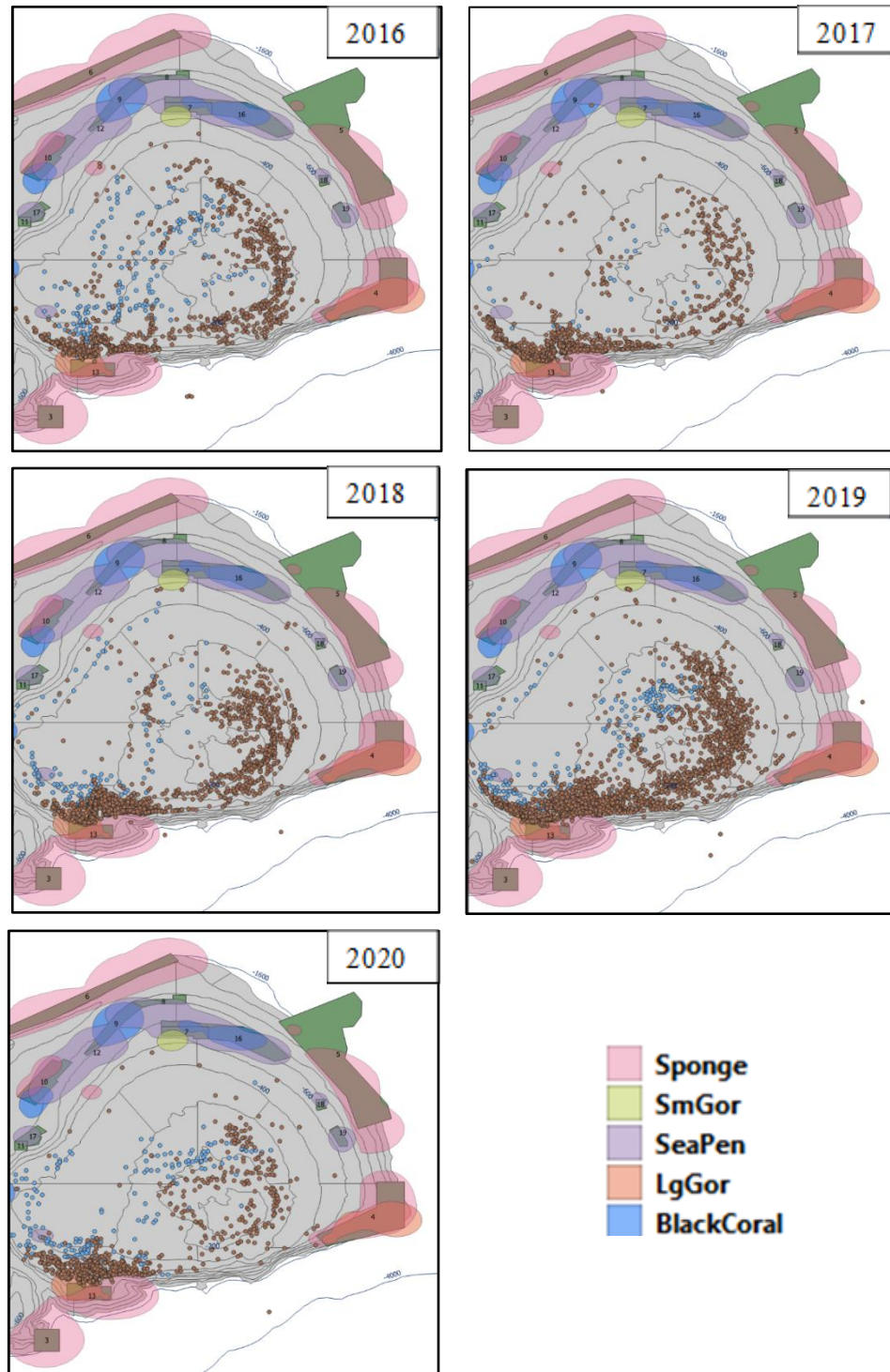


Figure 1a. Position of the hauls targeting cod by year and gear in the period 2016-2020. Brown circles represent trawl hauls and blue circles represent longline sets. The polygons defined for each VME taxa have been drawn in different colours and the areas closed to bottom fishing to protect the different VMS have been drawn in green and numbered.

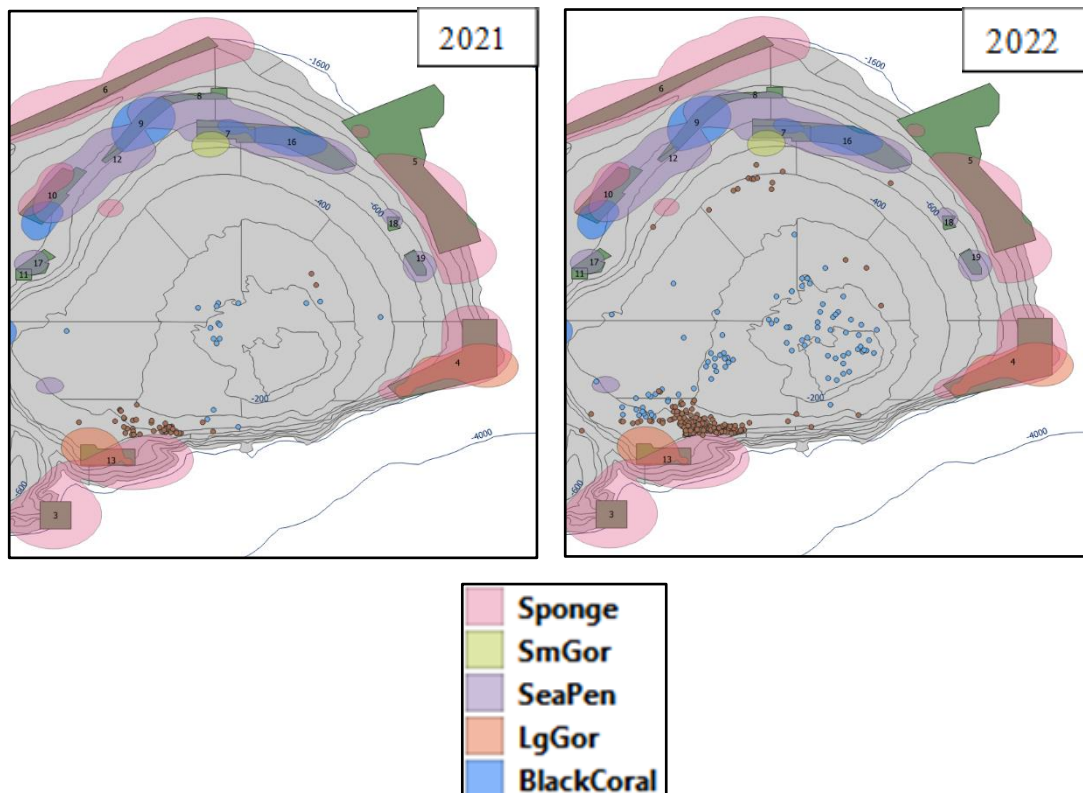


Figure 1b. Position of the hauls targeting cod by year and gear in the period 2021-2022. Brown circles represent trawl hauls and blue circles represent longline sets. The polygons defined for each VME taxa have been drawn in different colours and the areas closed to bottom fishing to protect the different VMS have been drawn in green and numbered.

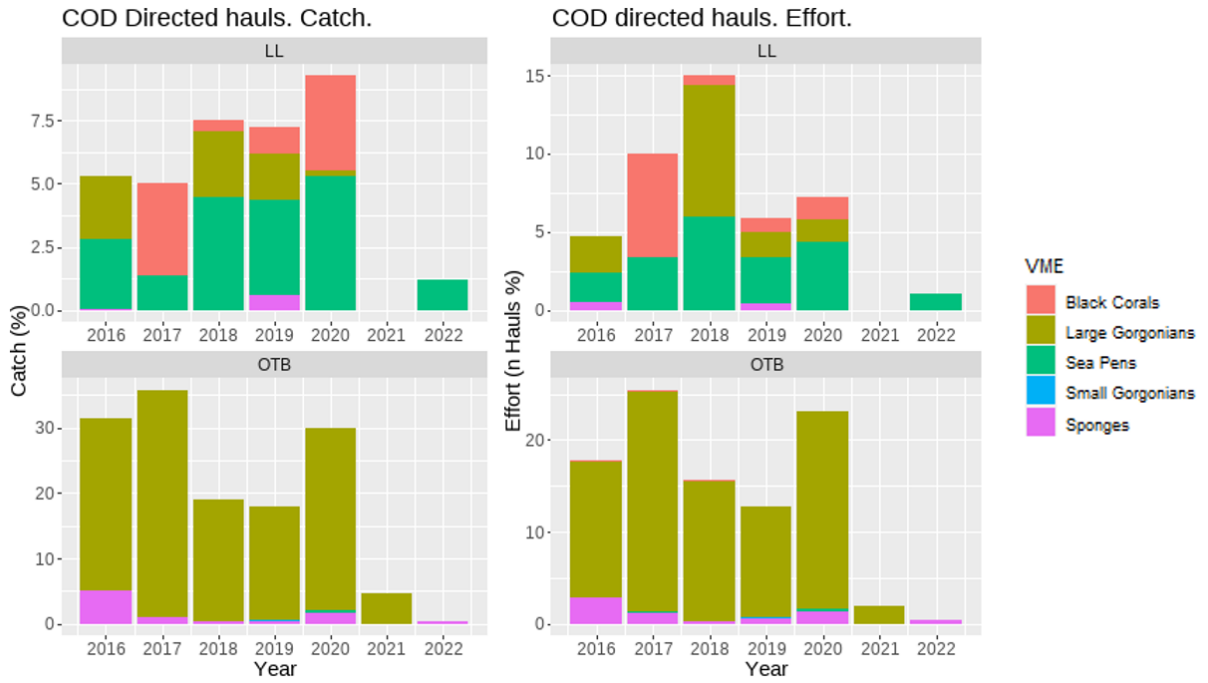


Figure 2. Percentage of cod catches and effort of hauls targeting cod by year and gear made in the different polygons of each VME indicator. a) Catches. b) Effort in number of sets.

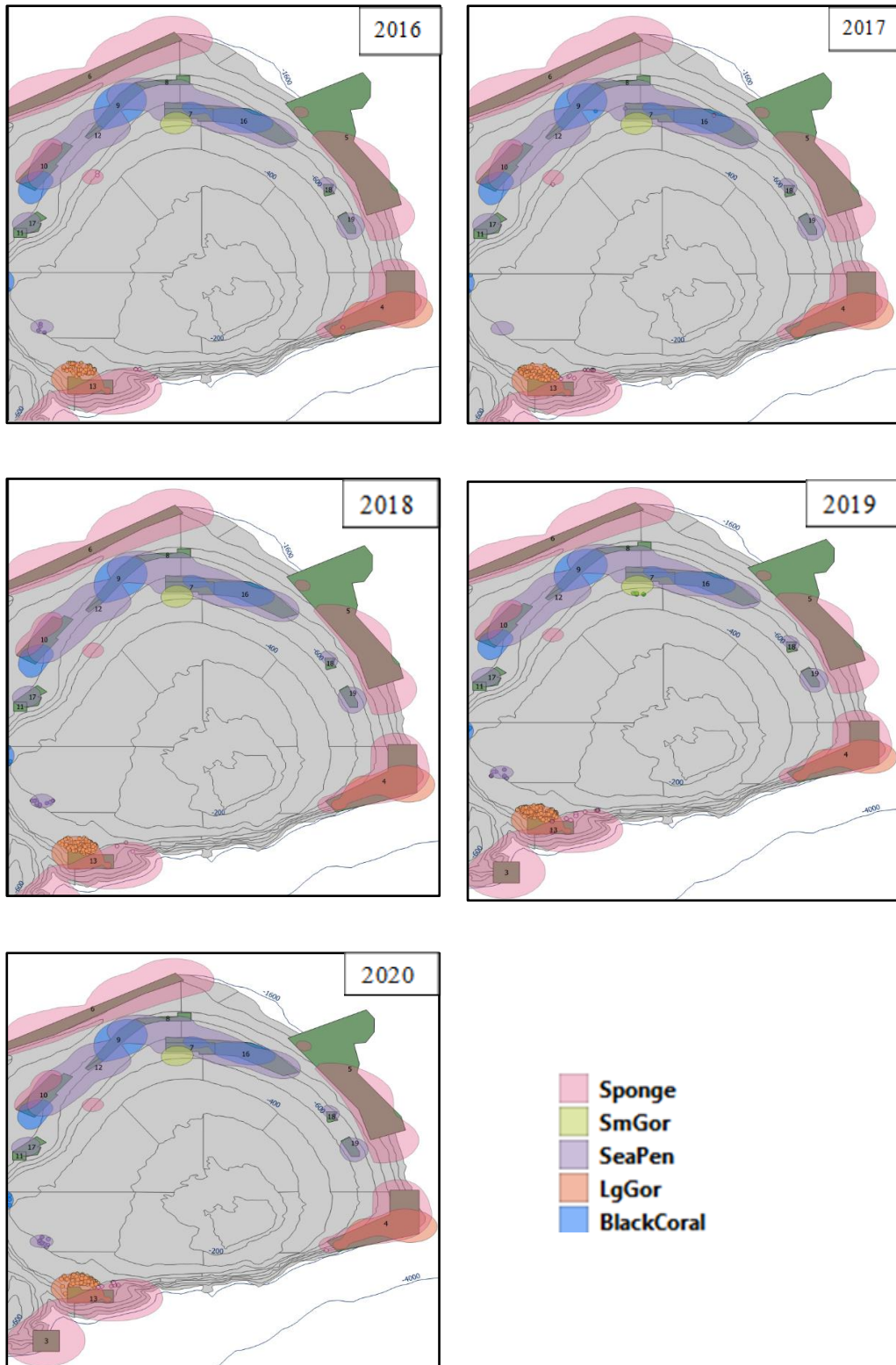


Figure 3a. Map with the position of hauls targeting cod in VME polygons by year. The polygons defined for each VME taxa have been drawn in different colours and the areas closed to bottom fishing to protect the different VMS have been drawn in green and numbered.

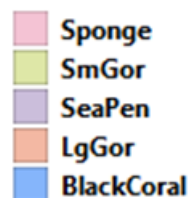
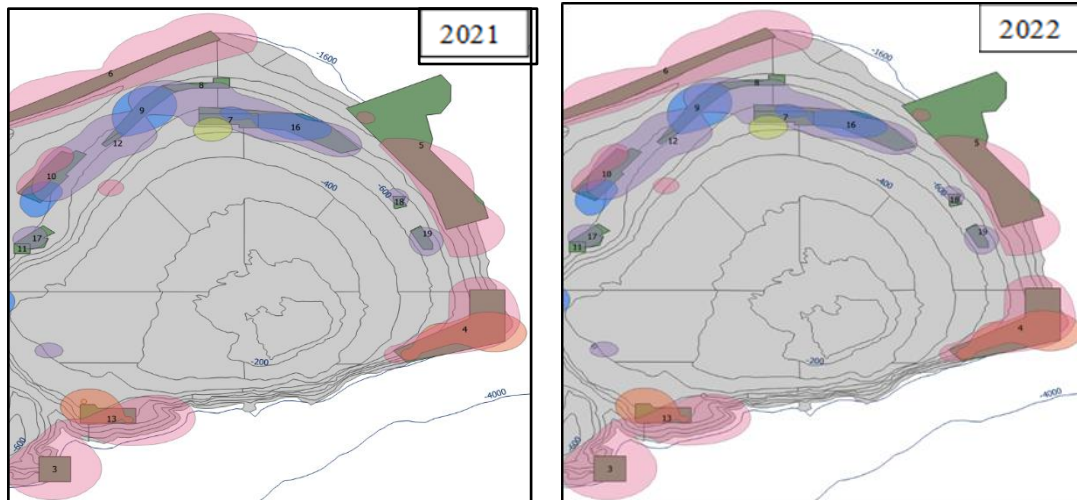


Figure 3b. Map with the position of hauls targeting cod in VME polygons by year. The polygons defined for each VME taxa have been drawn in different colours and the areas closed to bottom fishing to protect the different VMS have been drawn in green and numbered.

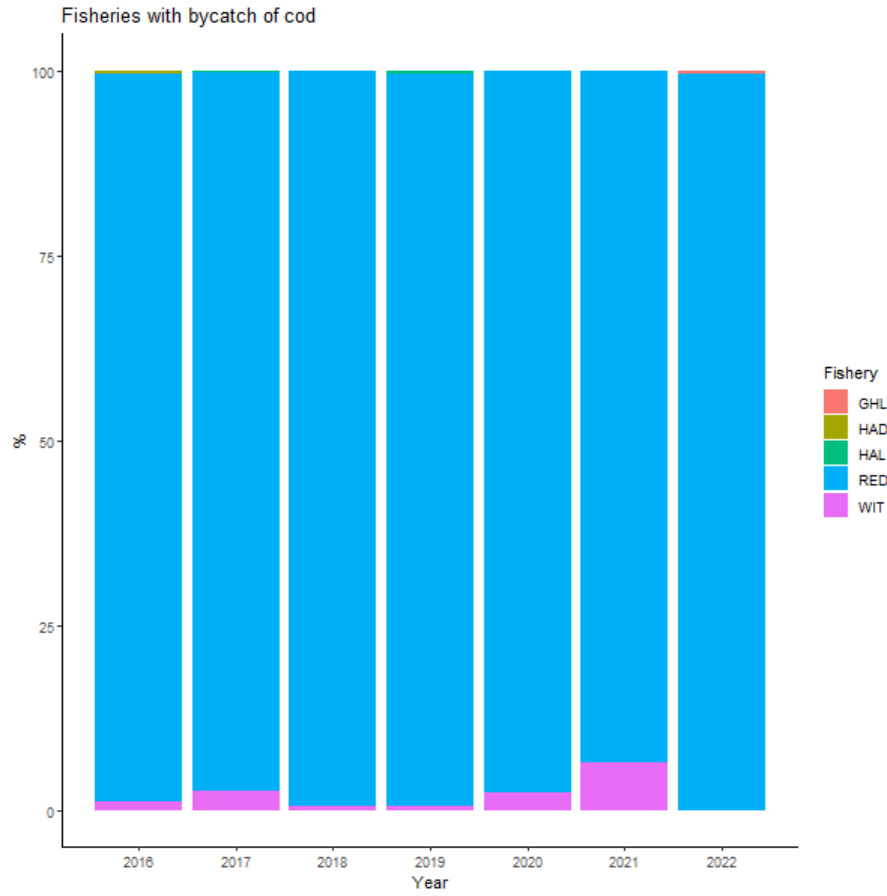


Figure 4. Percentage of cod catches caught as bycatch, by trawl fishery and by year.

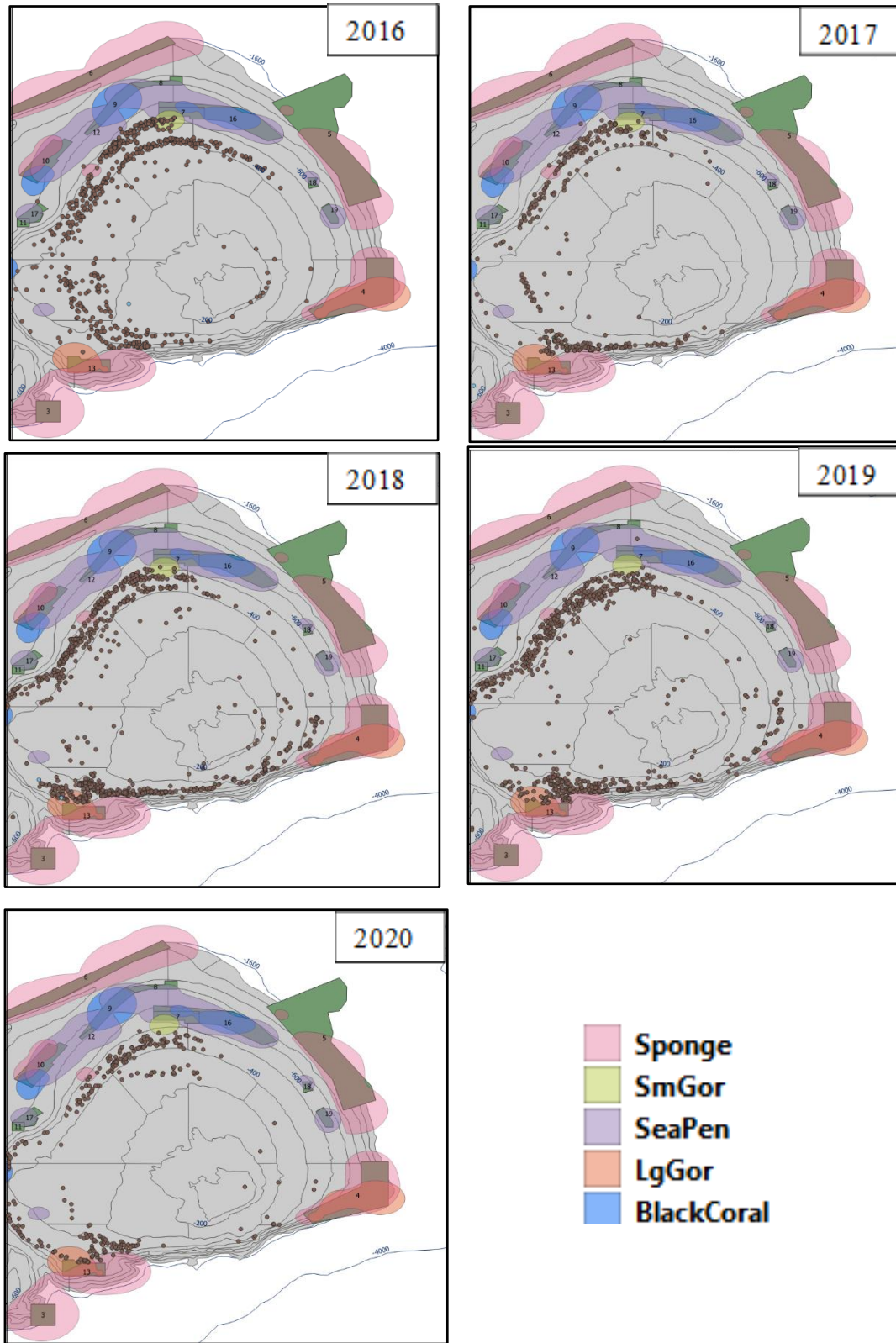


Figure 5 (a). Position of the hauls catching cod as bycatch by year and fishery for the period 2016-2020. Brown circles represent trawl hauls and blue circles represent longline sets.

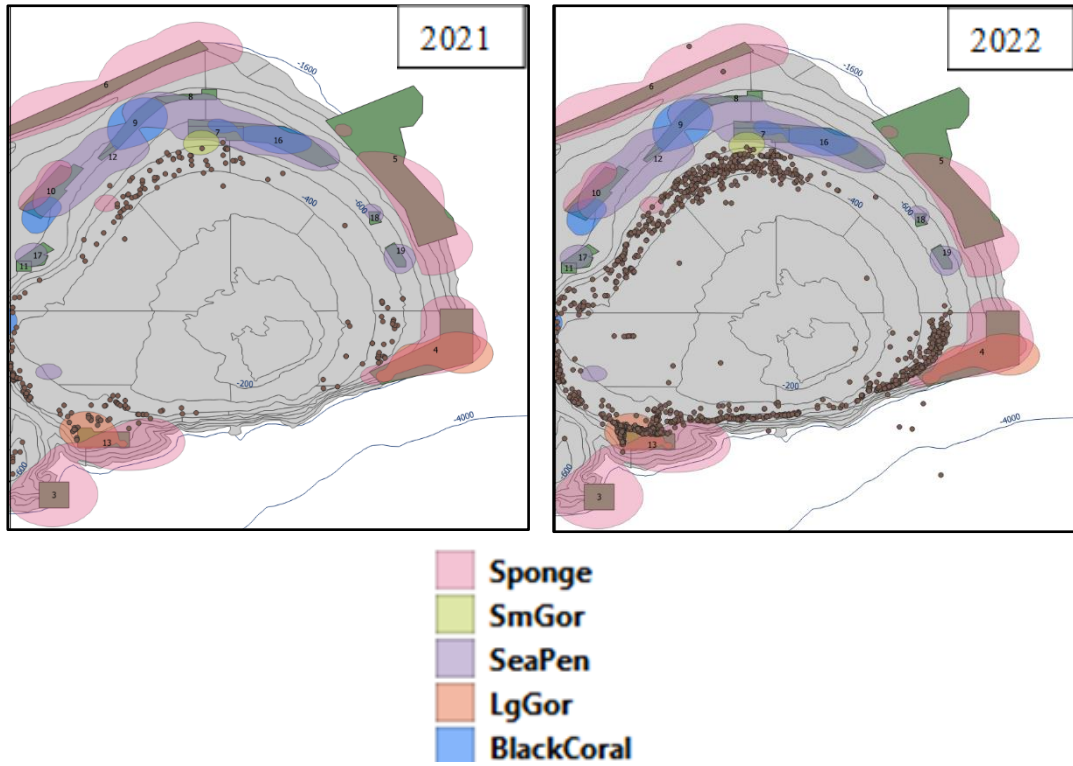


Figure 5 (b). Position of the hauls catching cod as bycatch by year and fishery for the period 2021-2022. Brown circles represent trawl hauls and blue circles represent longline sets.

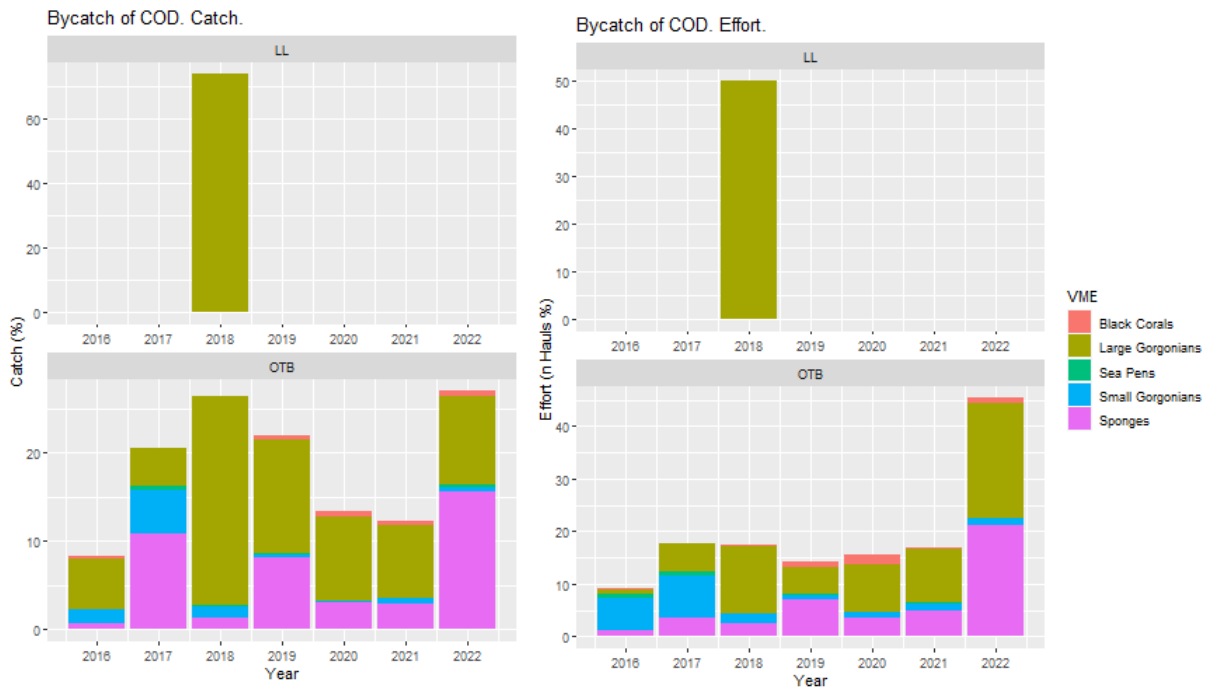


Figure 6. Percentage of cod bycatches and effort of hauls targeting other species by year and gear made in the different polygons of each VME indicator. a) Catches. b) Effort in number of sets.

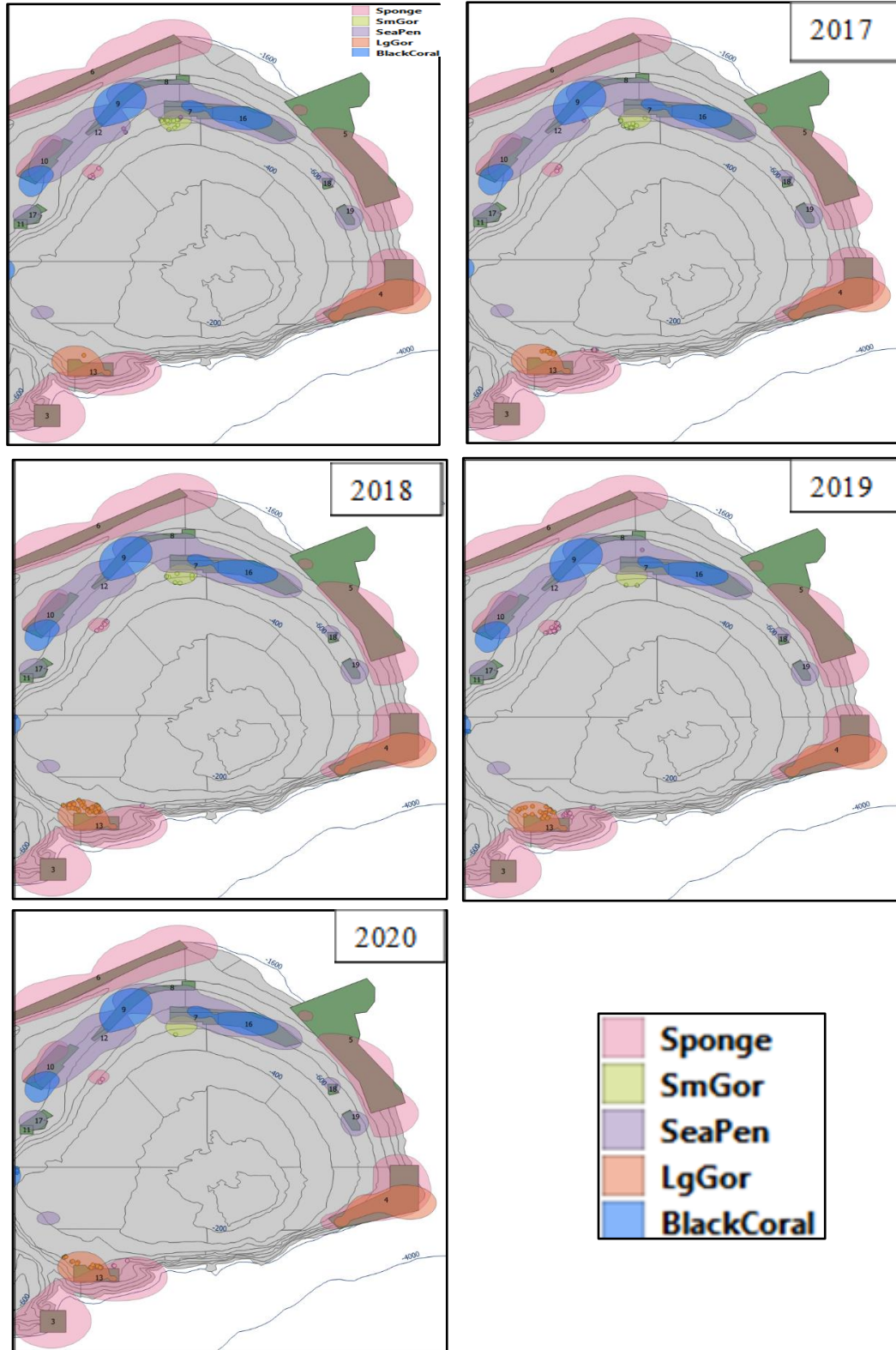


Figure 7 (a). Position of the hauls catching cod as bycatch in the VMW polygons by year for the period 2016-2020.

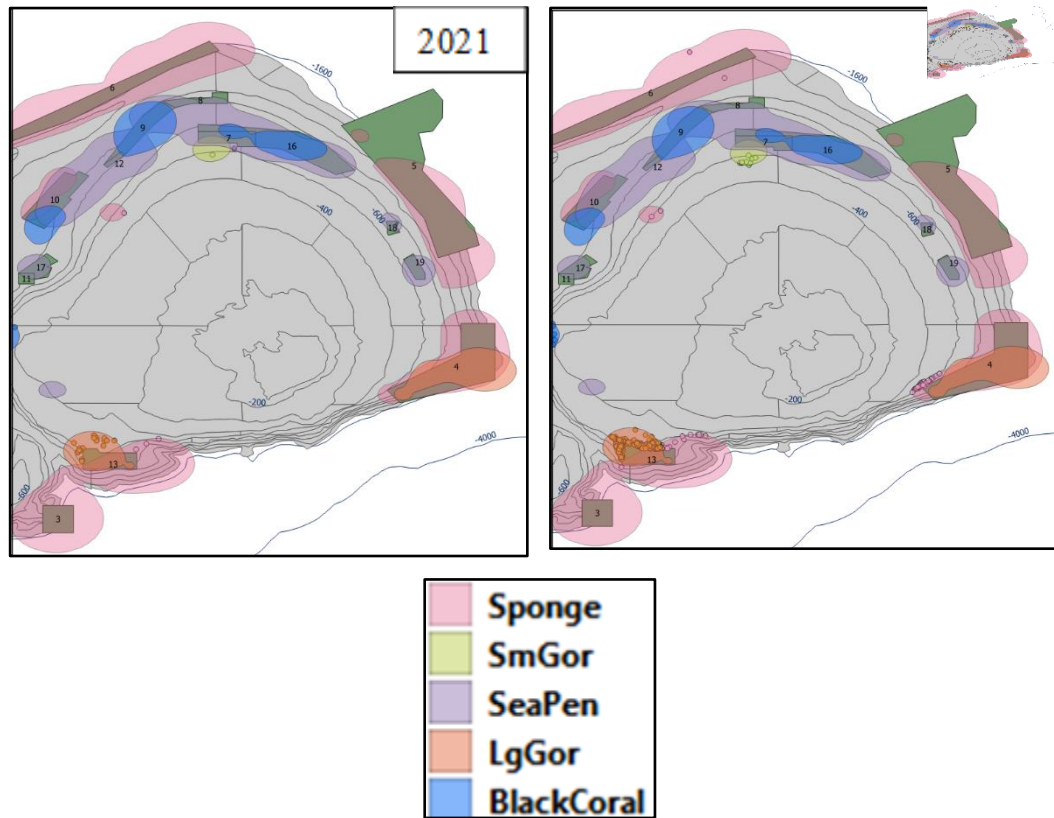


Figure 7 (b). Position of the hauls catching cod as bycatch in the VMW polygons by year for the period 2021-2022.

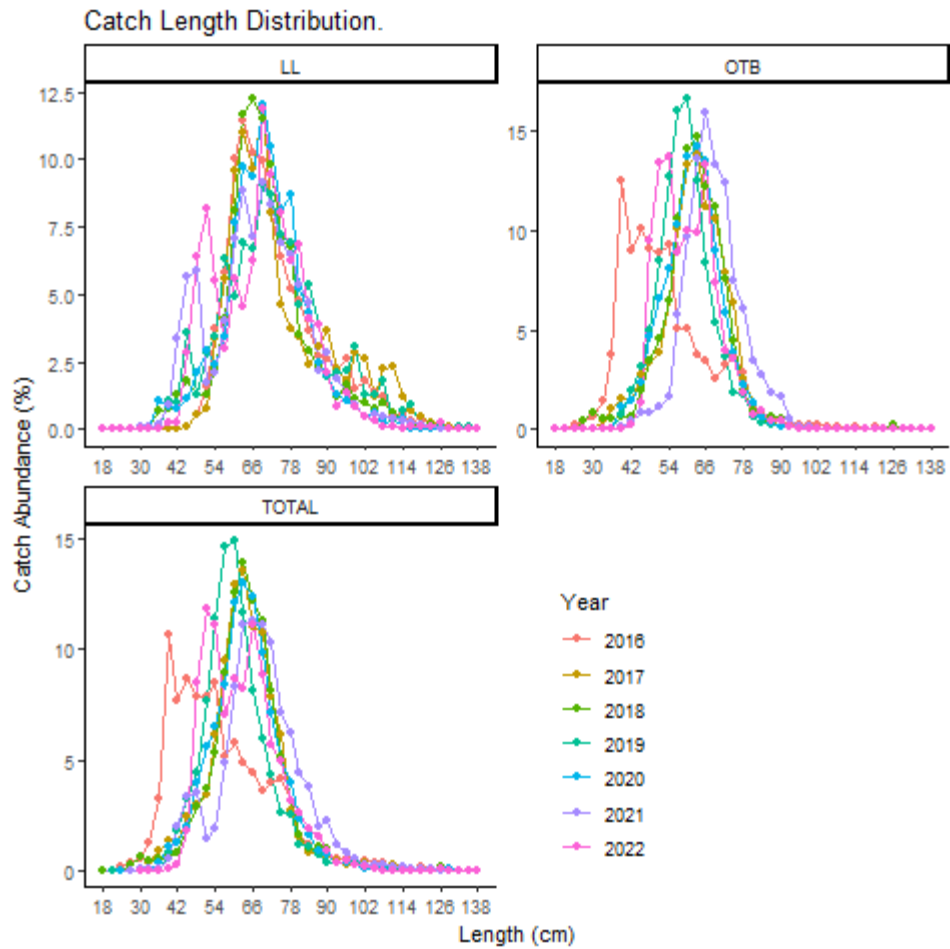


Figure 8. Cod catches length distribution in percentage by year for the longliners, trawlers and total catches for the period 2016-2022.

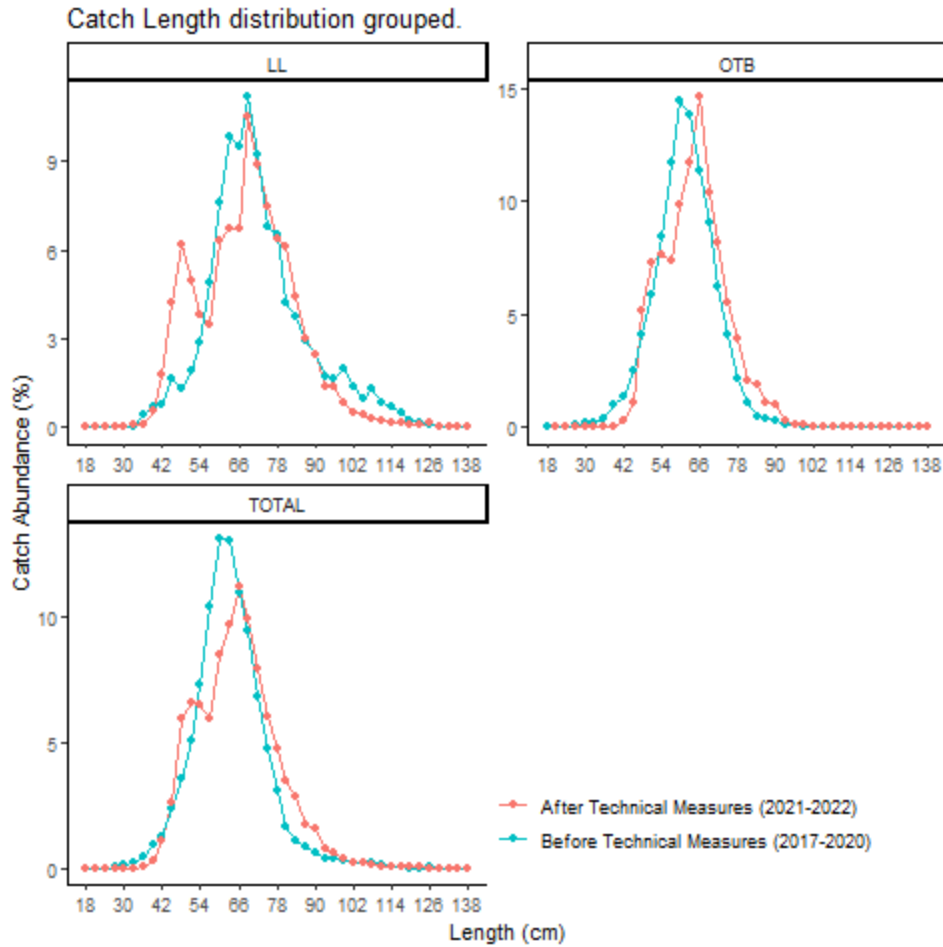


Figure 9. Cod catches length distribution in mean percentage for the period 2017-2020 and 2021-2022 for the longliners, trawlers and total.

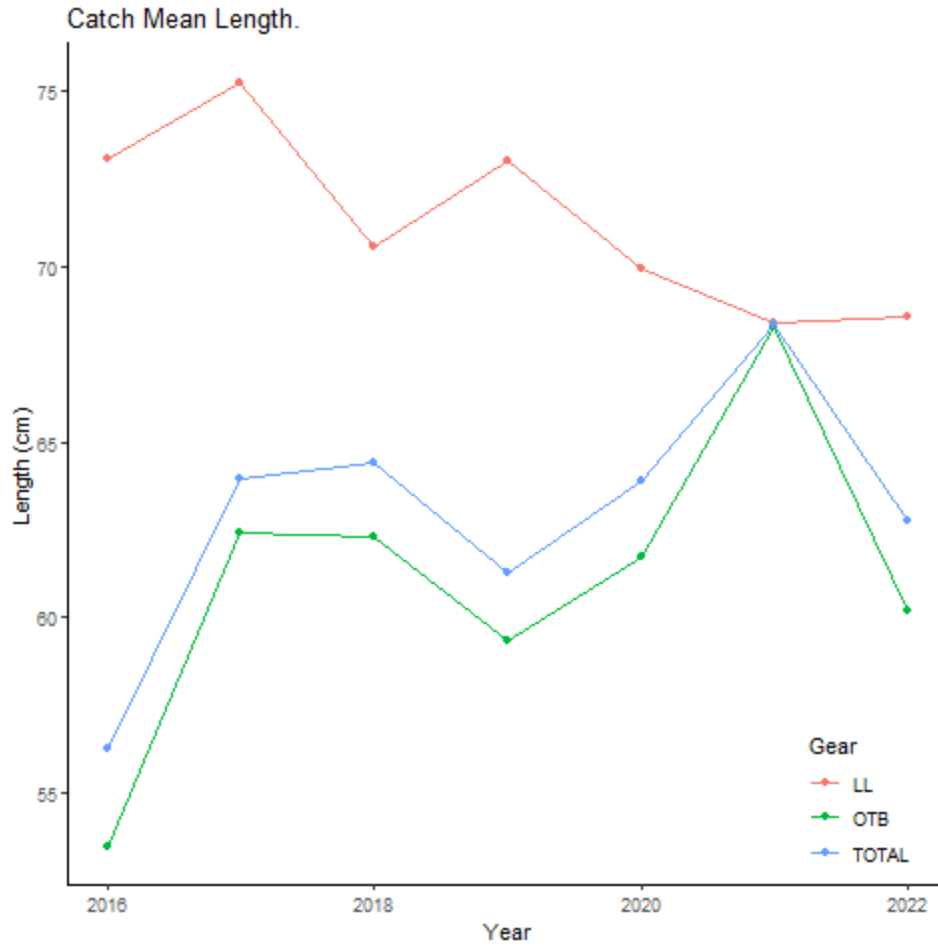


Figure 10. Mean length observed in the cod catches of longliners, trawlers and total catches by year in the 2016-2022 period.

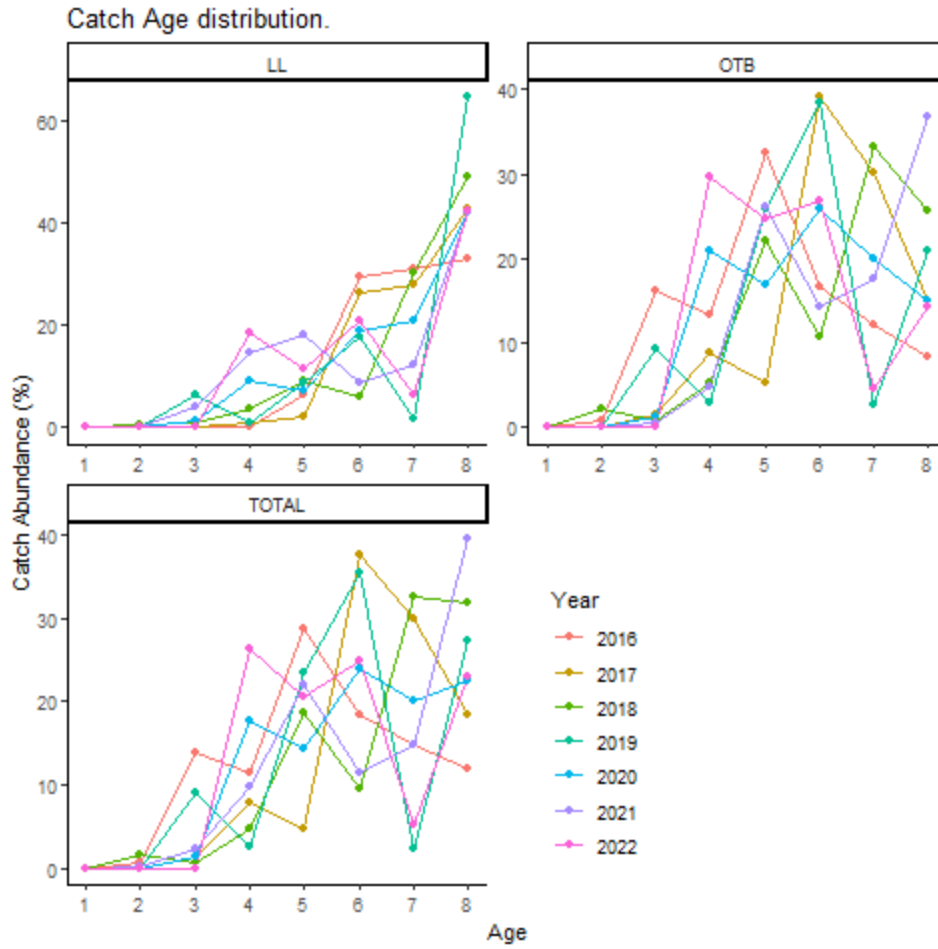


Figure 11. Age composition in percentage of the annual cod longline, trawlers and total catches for the period 2016-2022.

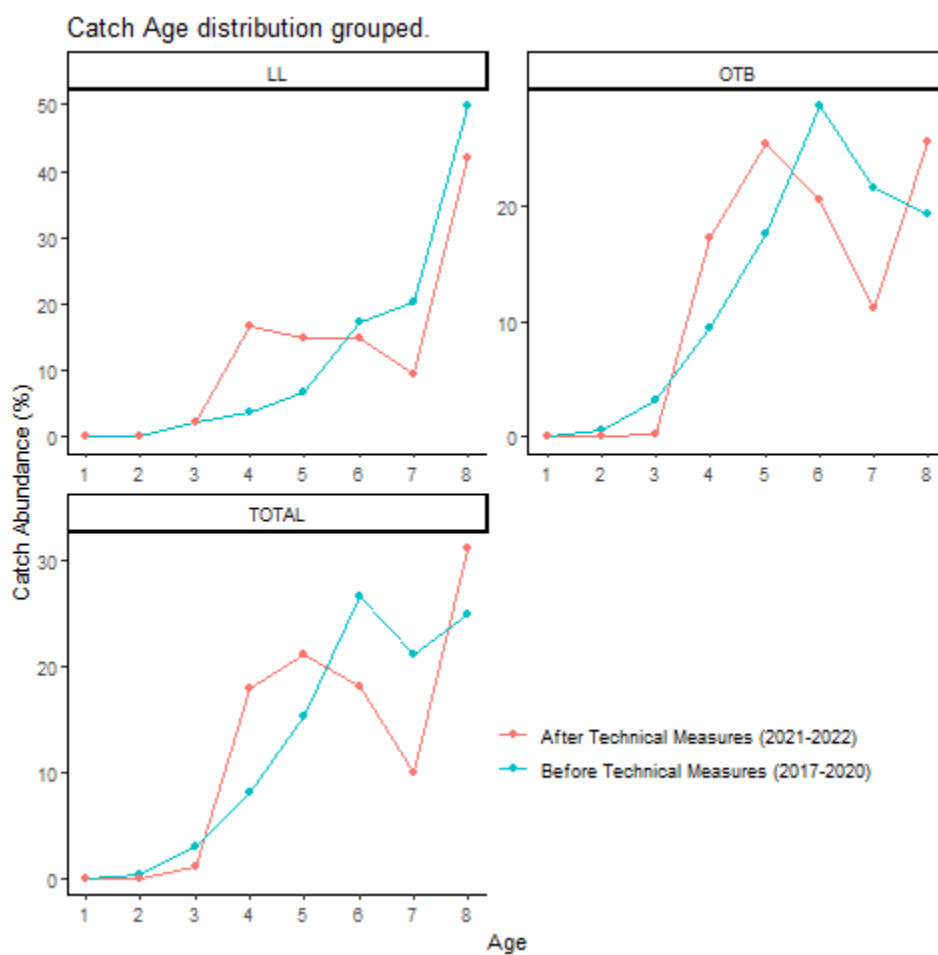


Figure 12. Age composition in mean percentage of the cod longline, trawlers and total catches for the period 2017-2020 and 2021-2022.