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Update on the analysis of VMS and Logbook data to study the bottom fishing footprint in the NAFO Regulatory Area: NEREIDA project

By

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Abstract

The objective of the ecosystem approach is to protect the structures, processes and interactions of the ecosystem through a sustainable use of the natural resources. A key step when applying the ecosystem approach is to assess the impact of the fishing activity in the ecosystems by defining the fishing footprint. The NEREIDA project, funded by the European Union through the NAFO Secretariat, addresses specific requests from the NAFO Commission in these regards and its findings are significant for the 2026 re-assessment of NAFO bottom fisheries.

There are two methodologies used to study the fishing effort and footprint in the NAFO Regulatory Area. The first one uses a simple speed filter to select the Vessel Monitoring System (VMS) pings most likely to be associated with fishing effort. The second one filters the VMS pings that correspond with the haul interval registered by the skipper in the logbook.

The aim of this study is to analyse the quality and coverage of the VMS and logbook data used in these two methods. Data gathered through the IEO Scientific Observer Program on board fishing vessels were used to assess both the coverage and accuracy of the data employed in studying fishing effort and footprint.

The findings reveal that both VMS and logbook databases contain errors, and that the effects of misreporting are amplified when these datasets are merged. Data from scientific observers allowed these errors to be quantified, with results indicating that approximately 40-70% of the original pings are retained for further analysis with the merging approach.

Despite this, the merging approach is widely considered an improvement in relation to the former method (i.e. simple speed filter) and represents a powerful tool for describing the spatial distribution of fishing activity.

However, these findings highlight that this improvement relies on the availability of high quality data with sufficient coverage.

The quality of information, both in the VMS system and in the logbooks, should be of concern to NAFO. Improving the quality of these data is crucial for better understanding the distribution of fishing effort and it directly impacts the accuracy of related analyses (i.e. Significant Adverse Impacts, fisheries footprint, fishing overlap with Vulnerable Marine Ecosystems, assessments, etc.).

Keywords: Vessel Monitoring System (VMS), logbook, NAFO, fishing effort, NEREIDA project.

Introduction

The objective of the ecosystem approach is to protect the structures, processes and interactions of the ecosystem through a sustainable use of the natural resources. To regulate the fishing activity in an ecosystem approach framework requires assessing the environmental impact of this activity.

A key step when conducting a study on the environmental impact of the fishing activity is the delineation of the fishing footprint (NAFO, 2009). At the 2020 NAFO Working Group on Ecosystem Science and Assessment (WG-ESA), an analysis of VMS and logbook data was presented to study the quality of the data used to delineate the bottom fishing footprint in the NAFO Regulatory Area (NRA) (Garrido *et al.*, 2020). During the 2023 WG-ESA, these analyses were updated, and the results are presented in this work. Conducted under the NEREIDA project, supported by the European Union through the NAFO Secretariat, this analysis is specifically crafted to fulfil specific requests from the NAFO Commission, with particular importance for the upcoming re-assessment of NAFO bottom fisheries scheduled for 2026, on which the distribution of the fishing effort and the overlap of NAFO fisheries with Vulnerable Marine Ecosystems (VMEs) will be characterized.

With the development of new technologies, it is possible to determine the vessel tracks by using the Vessel Monitoring System (VMS). The VMS uses the Global Positioning System (GPS) to accurately display the geographic position of the vessel. The satellite monitoring device transmits the information (geographic position, speed, course, etc.) from the vessel(s) to the Fisheries Monitoring Centres (FMCs), the land-based national centres to which registered fishing vessels connect via satellites. Vessel data is transmitted and received at specific time intervals, and each transmission of information is referred to as a "ping". The information received by the FMCs is then forwarded to the NAFO Secretariat in the cases where the vessels are working in the NAFO Regulatory Area (NRA).

Applying a speed filter is a very common method for identifying VMS pings associated with fishing activities (Thompson and Campanis, 2007; WGDEC, 2008; Campanis *et al.*, 2008, Campbell and Federizon, 2013). This approach involves filtering VMS pings through a straightforward speed filter directly related to fishing speeds. Thus, only the VMS records with a high likelihood of being associated with fishing effort are assigned as fishing activities. However, this procedure presents challenges in terms of threshold speeds across entire fleets/gears, leading to a misclassification of some pings at a rate that is difficult to quantify accurately (NAFO, 2017).

Use of the haul-by-haul data from logbooks permits VMS pings to be categorized as “fishing” or “non-fishing” based on whether they fall within fishing time intervals reported in the haul-by-haul data, instead of categorizing them by the vessel’s speed. That is, start and end of fishing timestamps from the logbooks are used to extract relevant VMS pings, which are then mapped in space to represent fishing effort and to delineate the fishing footprint. Because these VMS pings are directly within the reported fishing times interval, they are considered to be associated with fishing activity. Logbook data and VMS are complementary, and merging the datasets has already proven powerful for describing the spatial distribution of fishing activity with higher accuracy and precision than if each dataset was assessed independently (NAFO, 2018; NAFO, 2019).

The approach to track fishing effort by merging VMS and logbook data, which is widely considered an improvement of the former method (i.e. the simple speed filter), was first presented and used in 2017 in the NAFO framework to create fishery-specific effort maps and conduct an overlay analysis of VMEs and fishing footprint (NAFO, 2017).

In 2019, the WG-ESA developed the guidelines to create standard data products to study the fishing effort based on the available data (VMS and logbooks) (NAFO, 2019).

The main objective of this study is to analyse the quality and coverage of the available VMS and logbook data used in these two methods (speed-filtered & logbook filtered). Comparisons were made with data collected by the IEO Scientific Observer Program on board of trawl fishing vessels, as the information collected by these scientific observers is considered representative of the real effort exerted by the Spanish fleet. This analysis serves as a follow-up to the one conducted in 2020 (Garrido *et al.*, 2020).

Material

Vessel Monitoring System (VMS)

The NAFO VMS is a satellite-based monitoring system that provides data on the location, heading and speed of fishing vessels. All vessels operating in the NRA have been required to submit VMS data since the early 2000s, with a minimum ping rate which has improved from once every six hours in 2004 to hourly since 2011. The transmission of such data provides high resolution positions recorded at higher frequencies when compared to logbook data.

VMS data used in this study were supplied by the NAFO Secretariat, who is responsible for collecting and maintaining these data from fishing vessels operating in the NRA. In addition to being an integral part of the NAFO´s Monitoring, Control and Surveillance (MCS) scheme, the VMS data are also used in various scientific applications by NAFO (e.g. for the assessment of Significant Adverse Impacts (SAIs) on VMEs and in some fish stock assessments[1]).

VMS data include the following information: NAFO Vessel Identification; Flag State; Radio (vessel call sign); UTC date and time of the vessel position; vessel position by latitude and longitude; speed and heading (NAFO, 2023 REV).

Haul-by-haul (logbook data)

Haul-by-haul catch data are logbook data collected during fishing vessel activities. They provide details for each haul on catch and discards by species, type of gear used, timestamps and geographic coordinates for gear deployment and retrieval and geographic position collected during fishing vessel activities. The provision of these data is a responsibility of the skipper of each vessel (NAFO, 2023 REV).

The current logbook data format[2] (NAFO, 2023 REV) was implemented by NAFO in 2016, and was an improvement over 2015, when the haul data records included only the top three species caught by weight and did not include fishing timestamps. Haul-by-haul logbook data used in this study were also supplied by the NAFO Secretariat.

IEO Scientific Observer Program

[1] https://www.nafo.int/Fisheries/ReportingRequirements/VMS
[2] https://www.nafo.int/Fisheries/ReportingRequirements/LogbookInfo

The Instituto Español de Oceanografía (IEO, CSIC) employs scientific observers who are onboard during fishing operations conducted by the Spanish commercial fleet within the NRA. Around 30 % of the annually effort deployed by the Spanish fleet is sampled by the *IEO Scientific Observer Program*. The collection of these data falls under the responsibility of IEO, under the European Union Fisheries Data Collection Framework[3]. As in the haul-by-haul logbook data, full information of the gear deployment and retrieval is recorded (i.e. timestamps, geographic coordinates and depth), as well as the catch and discard weight by species.

It is important to note that the Spanish fleet is made up exclusively of trawlers, so the conclusions drawn at any point from the information obtained by the IEO observers may only be extended to the trawling fleet.

It is also important to highlight that due to administrative issues, the information recorded by Spanish scientific observers in the year 2020 is not considered in this analysis.

The data used for the analysis presented in this document correspond to the period from 2016 to 2022. This time interval aligns with the availability of the current format of the haul-by-haul catch data, ensuring the inclusion of the latest and most relevant information in the analysis.

Methodology

The analysis of the data was completed using the open-source statistical computing environment R (R Core Team, 2023). The implementation of this analysis involved the use of a script developed by Corinna Favaro from Fisheries and Oceans Canada (DFO). Originally developed for merging VMS and logbook data, the script was later modified and used in the overlay analysis of VME and fishing footprint under the NAFO NEREIDA project (NEREIDA, 2020). Further information about the script and the methodology can be found in Garrido et al. (2020).

General analysis of VMS and logbook databases errors

In many instances, both data sources (i.e. VMS and logbook) contain erroneous entries, namely: points with incomplete timestamps; incorrect vessel positions; duplicated records; headings outside compass range, etc. Following a deep review of the databases, a process of removal or flagging of erroneous entries was undertaken. Upon completion of the data cleaning procedure, the VMS and haul-by-haul datasets are joined using vessel identification and date as common fields between both datasets. This step holds particular significance, as the success of all subsequent analyses relies on accurately linking these datasets. The joined dataset only contains the pings (VMS data) of each vessel that coincide with the time reported as fishing in the logbook data, excluding pings from periods when vessels were not fishing.

Further analysis was conducted to identify potential errors in the merged dataset. These errors may be due to problems with the data in the logbooks or due to problems in the VMS data. Compared to the automated nature of VMS records, it is reasonable to assume that errors are more prevalent in the logbooks which rely on user input.

Analysis of the coverage based on the Spanish Scientific Observers trawl hauls

Given the potential presence of errors from both data sources, a subset of records in the joined database (VMS and logbooks) were selected for vessels which had a Spanish scientific observer on board. This selection aimed

[3] The EU's data collection framework (DCF) outlines the EU countries' obligations to collect, manage and make available a wide range of fisheries and aquaculture data needed for scientific advice (e.g. in the context of RFMOs such as NAFO). Member States' data collection activities are financially supported by the EU. https://oceans-and-fisheries.ec.europa.eu/fisheries/scientific-input/scientific-advice-and-data-collection_en#data-collection.

to assess the representativeness of errors in each data source, based on the assumption that the real effort exerted in these selected hauls was the one reported by scientific observers on board. Comparisons of the data sets were based on common fields, specifically the vessel ID and date.

To measure the coverage of the VMS and logbook data, an “ideal world” scenario was recreated, representing all the VMS pings in all the hauls with the presence of a Spanish scientific observer. By comparing the outcomes derived from this "ideal world" with the results obtained from the available data, it became possible to estimate the coverage of the VMS, logbook, and the merged VMS and logbook data information.

“Ideal world” scenario

In creating the "ideal world" scenario, an artificial database termed Hourly Ping Data (HPD) was generated. This database was constructed by generating a ping for every hour throughout the analysed period (January 1st, 2016 to December 31st, 2022). The HPD database only includes information on date and time. Thus, when merged with the observers’ records or logbooks, the same ping was assigned to every vessel conducting fishing activities at the same time within the NRA. This approach simplified the ping registry for all the analysed vessels.

The creation of the “ideal world” scenario involved merging the HPD with the dataset containing information from Spanish scientific observers. This integration enabled the derivation of the number of fishing trips, the count of hauls, the duration of each haul (measured in hours) and the expected number of VMS fishing pings. These were calculated under the assumption that the coverage of both VMS and logbook data was complete for these scientific observers' hauls.

Coverage of VMS

The coverage of the VMS system was evaluated by directly filtering the VMS dataset and the HPD by the records from the Spanish scientific observers, indicating the start and end of each haul. Since the “ideal world” scenario contains all the VMS pings that should be sent in those hauls, it can be compared with the number of pings actually sent. All the incorrect pings identified using this approach are then due to erroneous records in the VMS system.

Coverage of logbook

To analyse the haul coverage of the logbooks, the HPD dataset was filtered based on logbook entries, and, subsequently, hauls with the presence of a Spanish scientific observer were isolated. The outcomes of this analysis were then compared to the “ideal world” scenario, where HPD dataset was directly merged with these scientific observers’ records. The differences in the results can be attributed solely to differences in the records of the Spanish scientific observers and the skippers, highlighting, among other things, the number of hauls and fishing trips that are not documented in the logbooks.

Analysis of the performance of merging VMS and logbook datasets

Once the missing hauls and trips were identified, the performance of merging VMS and logbook data was analysed. This analysis involved comparing the outcomes from the "ideal world" scenario, where the HPD was directly merged with the records from Spanish scientific observers, with the results obtained from the "real world" scenario. In the "real world," the actual VMS data were merged with logbook entries and subsequently filtered based on records from scientific observers.

As a result, it became possible to assess the combined effect that a simultaneous lack of information in both datasets may have on the estimates of the effort deployed.

Results

General analysis of VMS and logbook databases errors

Errors in the VMS data

Table 1 presents the total number of pings and the number of erroneous entries in the VMS database by year. The identified errors include:

a) **Duplicated pings**: Entries with identical information regarding Vessel, Day and Hour.
b) **Incomplete pings**: Pings where any field is missing.
c) **Short pings**: Instances where the time interval between one ping and the next is less than one hour.
d) **Long pings**: Cases where the time interval between one ping and the next is more than one hour.

The percentage of incorrect pings ranges between 30.5 and 55.7%. However, it is important to note that not all the errors invalidate the data. Only duplicated and incomplete pings need to be removed from the effort analyses, since short and long pings can be used for the merging as long as the effort analyses considers the duration of the pings and is not only a sum of pings by grid.

Errors in the logbook data

Table 2 shows the total number of hauls recorded in the logbook by year along with the errors identified in this analysis, which can be classified as follows:

a) **Errors in the effort record**: These errors result from misrecordings of the start or the end of the haul and they translate into negative efforts (i.e. when the start of the fishing activity is recorded after the end), zero effort (i.e. when the start and the end of the activity are equal or either is missing) and big efforts (efforts exceeding 24 hours, often due to errors in recording the day, month or year of the start or end of the haul).
b) **Errors in the position record**: These errors pertain to inaccuracies in recording the position of start and/or end of the fishing activity.
c) **Errors in the gear record**: These errors, newly identified in this analysis, pertains to inaccuracies in recording the gear used for fishing.

Hauls with incorrect effort records in the logbook need to be removed before merging the datasets, as accurate start and/or end times are crucial for the merging process. However, hauls with errors in position records can be retained, as position data in subsequent analyses are derived from the VMS database, not from the logbook. It can be observed in table 3 the number of erroneous gear entries in the logbook, becoming evident that they are mainly due to human errors when entering the data. The gear is used to characterize the fishing effort by fishery, and only a further analysis considering position, season and catch composition, enabled the identification of the correct gear (OTB: otter trawls, LL: longlines).

Analysis of the coverage based on the Spanish Scientific Observers trawl hauls

The information collected by the Spanish scientific observers on board trawl vessels served to assess the coverage of both logbook and VMS, as well as the impact of missing information on the merged datasets.

With regards to the logbook coverage, it is clear that not all fishing trips and hauls documented by the Spanish scientific observers are recorded by the skippers in the logbook. Table 4 provides a summary of the number of trips and hauls recorded by the Spanish scientific observers, as well as the trips and hauls that are missing each year on the logbook. In 2016, all fishing trips with a Spanish scientific observer onboard were recorded in the logbook, while in the rest of the years at least one complete fishing trip was missing, three in 2022. Concerning the total number of hauls, on average, around 300 hauls are missing every year, with the percentage of missing hauls ranging from 22.7% (2019) to 60.2% (2022).

The number of hauls where no pings were received, resulting in exclusion from subsequent analysis, is indicated in Table 5. From 2016 to 2018 this represented 1 – 2 % of hauls. In 2019, this percentage increased to 6.1% with 42 missing hauls. In 2021 and 2022, the number of hauls without pings exceeded 100, representing more than 12% of the total hauls recorded by a Spanish scientific observer. Across all years, the total number of missing pings ranges from 535 – 1 366, which represents between 12.4 and 27.4%, depending on the year. Considering that the average duration of a single haul in the trawl fishery is around 5 hours, and VMS pings are recorded every hour, it is most likely that there are more hauls with some missing pings than hauls where all the pings are missing.

Finally, Table 6 illustrates the combined effect of errors when both datasets (VMS and logbook) are merged. The number of hauls that are excluded after datasets are merged increases slightly when compared to the excluded hauls described in Table 4. This is attributed to the fact that, in addition to those hauls that were not recorded in the logbook, hauls which were recorded but have no associated VMS pings are also removed.

When compared to Table 5 it is clear that merging the datasets resulted in a substantial increase in the number of pings excluded from further analysis. This is because pings for hauls that are not recorded in the logbook are not included in the merged dataset. As outlined Table 6, the percentage of missing pings ranges from 33.6-41.4% between 2016-2019 and 46.9-63.1% between 2021-2022.

Discussion

There are two methodologies to track the fishing effort deployed by the fishing fleet in the NRA. The first one uses a straightforward simple speed filter (0.5-5 knots) to identify and select the VMS pings most likely to be associated with fishing effort. Pings meeting the speed criteria are then assigned as fishing activities. The second one involves filtering VMS pings that correspond with the haul interval registered by the skipper in the logbook. Pings corresponding to the registered haul interval are then assigned as fishing activities (NAFO, 2017).

General analysis of VMS and logbook databases errors

Various issues have been identified in both the logbook and VMS data, and these errors may have an impact on the subsequent analyses conducted with the VMS, logbooks or the merged VMS and logbooks dataset.

In the logbook dataset, numerous errors have been detected, often stemming from mistakes made when records are being input into logbooks. These errors can have many different consequences. For instance, in hauls where the starting time is mistakenly recorded after the end time (logbook data), the information from the available pings (VMS data) for these erroneously entered hauls may be lost during the merging of both databases. Additionally, for logbook records where haul time is excessively long, the pings included in the merged (VMS and logbook) database may actually correspond with periods where the vessels are not fishing. In these instances, the number of pings erroneously assigned will depend on the duration error of the haul recorded in the logbook.

Although VMS pings are designed to be automatically sent by the vessel at a frequency of about an hour, technical issues in the transmission system can sometimes lead to deviations from this standard. While Thompson and Campanis (2007) found that such automatic transmission failures are uncommon in the NAFO regulatory area, the results presented in Table 1 indicate that every year around 30 to 50% of the received pings occur at frequencies different from one hour. This suggests that VMS data problems, such as over and under transmission, may have an effect on the analyses that rely on this source of information to estimate fishing effort in the NRA, regardless of the methodology used.

Analysis of the coverage based on the Spanish Scientific Observers trawl hauls

Measuring the extent of errors in the VMS and logbook data is challenging due to inherent issues in both datasets. In order to assess the possible scope of these errors, an analysis of the merged VMS and logbook datasets procedure was conducted. This analysis relied on recreating the “ideal world” scenario using trawl data from Spanish scientific observers. In this analysis it was assumed that the actual effort exerted was precisely recorded and computed by these scientific observers.

Analysing the results, two primary sources of missing data were identified:

a) **Misreporting in the logbook**: Not all the hauls and/or fishing trips are recorded in the logbook (Table 4). This discrepancy can be attributed to various reasons, including submission issues or inappropriate formats, as highlighted by the NAFO CESAG Working Group (NAFO, 2018b). Within recorded trips, diverse factors contribute to missing information. It has been observed that the last hauls of a fishing trip are sometimes missing. Additionally, some logbook entries appear to amalgamate data from multiple hauls, grouping catch information and effort data from different hauls.
b) **Misreporting in the VMS system**: Each year around 12-27% of the pings that should be associated with hauls reported by the Spanish scientific observers are missing (Table 5). The cause of these errors should be further investigated to correct them and improve the quality of the VMS.

After merging the VMS and logbook datasets, it becomes evident that the effects of the misreporting are amplified when there is missing information in both sources of data. Missing hauls result in pings be discarded, while missing pings may lead to the exclusion of documented hauls from logbooks. Once the datasets are merged, just 40-70% of the original pings are retained, illustrating the magnitude of the potential impact that errors (due to missing pings or missing haul records) can have on subsequent and related analyses.

Conclusions

It is important to note that the conclusions drawn here would only be applicable to the overall NRA trawl data if the sample data used (the Spanish scientific observers’ data) was representative of VMS and logbook data provided by all trawl fleets operating in the NRA. This sample represents around 9% of the total NAFO logbook data from 2016-2022. However, based on the data provided by the NAFO Secretariat for this analysis, even if the errors quantified for the Spanish fleet is not representative of all the trawl fleets operating in the NRA, the operational problems identified in the VMS and recording errors in the logbook datasets is likely to impact all fleets to some degree

Issues in VMS data transmission (i.e. including both over- and under- transmission), and in logbook data (i.e. missing trips and/or haul information) can significantly impact any analysis that relies on this information to estimate the fishing effort exerted by the fleet.

The merging of VMS and logbook data highlights that the effects of the misreporting are magnified when data coverage is less than 100%. When both datasets were merged, only around 40-70% of the expected pings, according to the “ideal world scenario”, were considered. It is important to note that the impact of these problems (in logbook and VMS databases) on the estimation of fishing effort was not the primary objective of the current analysis. Further analyses should be conducted in order to determine them.

The quality of the information in both the VMS system and the logbooks should be of concern for NAFO. Improving the quality of these datasets is crucial for developing a more comprehensive understanding of effort distribution and directly impacts the accuracy of related analyses (i.e. SAI, fisheries footprint, fishing overlap with VME, assessments, etc).

The analyses conducted under the NEREIDA project are of great practical utility, as they contribute to meeting specific requests from the NAFO Commission, with particular relevance to the upcoming reassessment of NAFO bottom fisheries, scheduled for 2026.

In summary, addressing VMS and logbook data challenges, enhancing data coverage, and improving overall data quality are essential steps for advancing research on effort distribution and undertaking related tasks critical to effective fisheries management.

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Table 1. VMS total pings and erroneous entries for the period 2016-2022.

	Total Pings	Duplicated	Incomplete	Short	Long	Wrong (Total)	Wrong (%)
2016	90 294	9 922	0	17 751	5 383	33 056	36.6
2017	64 151	7 933	0	8 352	4 498	20 783	32.4
2018	212 674	81 478	0	30 219	6 813	118 510	55.7
2019	143 031	26 149	0	36 901	5 841	68 891	48.2
2020	142 127	25 372	0	43 638	6 315	75 325	53
2021	127 297	23 050	0	27 734	6 895	57 679	45.3
2022	94 872	10 676	1	13 467	4 798	28 942	30.5

Table 2. Logbook hauls and erroneous recordings for the period 2016-2022.

	Total hauls	Misrecorded Effort				Misrecorded positions	Misrecorded gear
		Negative	Zero	Big	Total		
2016	7 697	101	12	151	264	9	1 346
2017	6 460	143	59	149	351	26	1 027
2018	8 194	146	7	171	324	11	564
2019	11 358	608	158	260	1 026	156	1 801
2020	12 007	155	139	119	413	2 610	417
2021	8 341	109	918	115	1 142	569	243
2022	8 700	58	1 138	186	1 382	9	256

Table 3. Logbook misrecorded gears and new gears assigned. Count represents the total for the period 2016-2022. OTB refers to otter trawl gears and LL to longline sets.

Gear type	Count	New gear
	237	LL
OTB	2	OTB
#N/A	69	
0TB	2	OTB
1	2	LL
2	7	LL
3	28	LL
4	1	LL
5	6	LL
6	1	LL
???	74	OTB
???-2	45	OTB
???1	13	OTB
???2	290	OTB
LLS	259	LL
OBT	1 915	OTB
OT	201	
OTB-2	190	OTB
OTB2	2 360	OTB
OTM	304	
OTW2	34	OTB
TB	67	OTB
TBS	1 254	
TO	52	OTB

Table 4. Number of fishing trips and number of hauls recorded by the Spanish scientific observers and by the skipper in the logbook, corresponding to the trawl fishing trips where an observer was present. The differences in number and percentage are also shown.

	Observers		Logbook		Difference (n)		Difference (%)	
	Trips (n)	Hauls (n)	Trips (n)	Hauls (n)	Trips	Hauls	Trips	Hauls
2016	7	927	7	691	0	236	0.0	25.5
2017	8	739	6	503	2	236	25.0	31.9
2018	7	685	5	399	2	286	28.6	41.8
2019	6	688	5	532	1	156	16.7	22.7
2020	-	-	-	-	-	-	-	-
2021	8	845	7	498	1	347	12.5	41.1
2022	8	796	5	317	3	479	37.5	60.2

Table 5. Number of VMS pings that should be received (i.e. "Ideal world" scenario) and number of pings actually received (i.e. "Real world" scenario) when filtering VMS pings by the trawl Spanish scientific observers' records. Also, the percentage of missing pings and the number and percentage of hauls where no ping was sent are shown.

	Ideal	Real	Missing pings		Missing hauls	
	Pings (n)		(n)	(%)	(n)	(%)
2016	5 194	4 213	981	18.9	9	1.0
2017	4 597	3 557	1 040	22.6	15	2.0
2018	4 311	3 776	535	12.4	7	1.0
2019	4 026	2 924	1 102	27.4	42	6.1
2020	-	-	-	-	-	-
2021	5 445	4 229	1 216	22.3	115	13.6
2022	5 332	3 966	1 366	25.6	102	12.8

Table 6. Number of fishing trips and hauls recorded by the Spanish scientific observers on board trawlers, and ideal pings associated ("Ideal world" scenario). Also, the number of fishing trips, hauls and pings obtained after merging logbook and VMS and selecting the hauls where a Spanish scientific observer was aboard ("Real world" scenario). The differences between them are presented as a percentage.

	Ideal (n)			Real (n)			Difference (%)		
	Trips	Hauls	Pings	Trips	Hauls	Pings	Trips	Hauls	Pings
2016	7	927	5 194	7	682	3 113	0	26.4	40.1
2017	8	739	4 597	6	497	2 720	25	32.7	40.8
2018	7	685	4 311	5	396	2 528	28.6	42.2	41.4
2019	6	688	4 026	5	500	2 673	16.7	27.3	33.6
2020	-	-	-	-	-	-	-	-	-
2021	8	845	5 445	7	493	2 894	12.5	41.7	46.9
2022	8	796	5 332	5	316	1 968	37.5	60.3	63.1