VERIFICATION OF THE LIMITATION OF THE NUMBER OF FADS AND BEST PRACTICES TO REDUCE THEIR IMPACT ON BY-CATCH FAUNA

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SUMMARY

This document presents the verification of two initiatives of the Spanish tuna purse-seiners organizations ANABAC and OPAGAC to monitor better FADs and to reduce their effects on the pelagic ecosystem: the limitation of the number of FADs (in force in the Indian Ocean and to be implemented in the Atlantic Ocean in 2016) and the application of good practices to reduce FAD-associated fauna mortality. This verification is based on data transmission by buoy manufacturers and data processing through R, and on in-situ registration by observers of fauna release operations and FAD characteristics. Fauna release in the Atlantic Ocean in 2015 had a global conformity rate of 74%. The critical parameter was the size of the animals. Boats with initially lower levels of compliance showed significant progress. Non-entangling rafts were observed on over 90% of FADs, and non-entangling submersed structure on around 80%. In the Indian Ocean, we found no record beyond the daily limit set by IOTC, and observed an important decreasing trend during the last quarter of 2015, with a reduction by 33% of the number of active FADs.

RÉSUMÉ

Le présent document porte sur la vérification de deux initiatives d'organisations de senneurs thoniers espagnols, ANABAC et OPAGAC, dans le but de faire un meilleur suivi des DCP et de réduire leurs effets sur l'écosystème pélagique : la limitation du nombre de DCP (actuellement en vigueur dans l'océan Indien et qui sera mise en œuvre dans l'océan Atlantique en 2016) et l'application de bonnes pratiques visant à réduire la mortalité de la faune associée aux DCP. Cette vérification est fondée sur la présentation de données par les fabricants de bouées et le traitement des données en R, ainsi que l'enregistrement in situ par les observateurs des opérations de remise à l'eau de la faune et des caractéristiques des DCP. Le taux total de conformité de la faune remise à l'eau dans l'océan Atlantique en 2015 s'élevait à 74%. La taille des animaux constituait le paramètre critique. Les navires présentant un faible niveau d'application ont affiché des progrès considérables. Des radeaux non emmêlants ont été observés dans plus de 90% des DCP et des structures submergées non emmêlantes dans environ 80%. Dans l'océan Indien, aucun registre n'a été localisé au-delà de la limite journalière fixée par la CTOI et une tendance décroissante importante a été observée au cours du dernier trimestre de 2015, présentant une réduction de 33% du nombre de DCP actifs.

RESUMEN

Este documento presenta la verificación de dos iniciativas de las organizaciones española de cerqueros atuneros, ANABAC y OPAGAC, para hacer un seguimiento mejor de los DCP y reducir sus efectos en el ecosistema pelágico: la limitación del número de DCP (vigente en el océano Índico y que se va a implementar en el océano Atlántico en 2016) y la aplicación de buenas prácticas para reducir la mortalidad de la fauna asociada con los DCP. Esta verificación se basa en la transmisión de datos por parte de los fabricantes de la boya y en el procesamiento de los datos mediante R, así como en un registro in situ de los observadores de las operaciones de liberación de fauna y de las características de los DCP. En el océano Atlántico en 2015 hubo una tasa de cumplimiento del 75% en lo que concierne a la liberación de la fauna. El parámetro crítico era la talla de los animales. Los barcos que inicialmente tuvieron bajos niveles de cumplimiento han realizado importantes progresos.

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KEYWORDS

Effort control, buoys, non-entangling FADs, by-catch mitigation, observers, purse-seine

1. Introduction

The use of fish aggregating devices (FADs) is very widespread in tropical tuna purse-seine fisheries. Using FADs allows a higher fishing efficiency through reducing searching time, fuel consumption and the probability of null sets. However this widespread use raises the need to monitor better the FADs, to limit the fishing effort, and to reduce their impact on FAD-associated fauna (entangling, by-catch).

Through the adoption of Resolution 15/08 by the IOTC (Indian Ocean Tuna Commission) and Recommendation 15-01 by ICCAT, the maximum number of instrumented buoys active at sea at any one time in relation to each purse seine vessel is set at 550 for the Indian Ocean and 500 for the Atlantic Ocean, and the maximum number of instrumented buoys that may be acquired annually by each fishing vessel is set at 1100 for the Indian Ocean. In addition to Resolution 15/08, Spanish purse seiner organizations ANABAC and OPAGAC established for the Indian Ocean an agreement to limit the use of FADs and to control this limitation. This document presents the system of verification that will be used for ANABAC and OPAGAC fleets.

The second part of the document will present the system of verification of the code of good practices established in February 2012 by ANABAC and OPAGAC regarding FAD design and release of FAD-associated sensible fauna (selaceans and turtles). The goal of this self-imposed initiative is to reduce the mortality by entangling or by incidental catch of this fauna.

In order to assess the actual level of application of these good practices in the fleet, a system of verification is being implanted in the vessels of the ANABAC and OPAGAC fleets. This verification is based on in-situ registration of the good practices by observers, which implies a 100% coverage of the fleet by observers. We present here the training for observers, and the first data of good practices observed in the Atlantic and Indian Ocean.

2. Methods

2.1 Definitions

The resolution 15/08 and recommendation 15-01 apply to purse seine vessels fishing on Drifting Fish Aggregating Devices (DFADs), equipped with instrumented buoys for the purpose of aggregating tuna target species, in the respective IOTC and ICCAT areas of competence. These documents defines an instrumented buoy as a buoy with a clearly marked reference number allowing its identification and equipped with a satellite tracking system to monitor its position. The agreement between ANABAC and OPAGAC integrates the requirements defined by resolution 15/08 and states explicitly further requirements such as the prohibition of radio buoys or the necessity of correspondence between the number of active buoys at sea and the number of FADs in use (i.e. no FAD without active buoy).

The state of a buoy is defined by four possibilities:

- Operational buoy: after leaving factory and going through transit, buoy that is put in operation and has capacity to transmit
- Active buoy: operational buoy located at sea
- Deactivated buoy: through request from skippers (due to loss, removal by other vessel or voluntary deactivation), buoy that is put out of service by manufacturers and stops transmitting. The deactivation of a buoy is detected by its disappearance from the data transmitted (see 2.2.).
- Reactivated buoy: through recovery at port and request from skippers, buoy that is put in operation again and has capacity to transmit again.

2.2 Control of the number of buoys purchased and being used

The control system needs to be able to monitor the purchase of buoys by each fishing company to each buoys manufacturer, as well as the use of active buoys.

To this purpose, each buoy manufacturer will provide AZTI with the monthly bills of communications/transmissions of the buoys. Moreover, each manufacturer will emit a certificate for each tuna purse seiner, confirming that they did not give a service of communications/transmissions for other buoys than the ones mentioned in the bills and data files sent to AZTI.

Precise requirements were provided to the manufacturers regarding the data files to be sent to AZTI.

The files are sent monthly and individually (per vessel), and include all records of active buoys corresponding to each purse seine vessel in the concerned month. The files are sent with one month lag from the last day of activities included therein; that is, the information of the month of October 2015 was sent on December 1st 2015. The name of each file is: X-YYYY-MM-IMONUMB.csv, that is four alphanumeric codes separated by a hyphen, where:

- X [1 digit] code of buoy manufacturer
- YYYY [4 digits]: Year
- MM [2 digits] month
- IMONUMBER [7 digit] IMO code of the vessel

The files will include each day of the month. The following information will be provided for each and every of the active buoys: date (including time), number of buoy, position and speed, following format specifications given in **Table 1.**

The data will be processed with the software R (http://www.r-project.org/) using a data preparation followed by a 3-part routine (Annex 1 to 4). First, data are prepared and gathered into a unique csv file. Then, in the first part, the vessel is selected and the total number of operational buoys in a given month is determined. For the vessels for which this number is below 550, the processing stops at the end of the first part. In the second part, the total number of active buoys at sea in a given month is determined, i.e. the active buoys with a velocity superior to 0.01 knots and inferior to 6 knots. For the vessels for which this number is below 550 (Indian Ocean) or 500 (Atlantic Ocean), the processing stops at the end of this second part. In case we will observe a vessel with more than the maximal authorized number of buoys at sea in a given month, a third part will be applied in order to determine the number of active buoys at the sea each day of the analyzed month for this vessel. If after applying the third part we identify a vessel with more than 550 at sea on a given day of the analyzed month, a notification will be sent to the company.

2.3 Traceability and prevention of fraud

Each buoy deployed at sea must be registered in the FAD logbook, with its position, date and time. If a buoy is declared days later than its actual deployment, there will be a discrepancy between the position of the buoy in the data files and the position recorded in the FAD logbook. An additional checking can be done using VMS files if there are doubts on the reliability of the FAD logbook data. A supplementary cross-check can be done using the data registered by observers (form D registering the buoy number of each FAD planted, visited or fished).

Similarly, if a buoy is deployed without activating it, with the intention to activate it later, the same discrepancies can be detected.

In the cases of buoys recovered at port (e.g. buoy previously removed by another vessel and returned to its owner at port), they will be checked in situ before being put in operation again by the manufacturers. This in situ checking will be done by shipping agents in a provisional period and then by the fisheries offices.

2.4 Skippers' information

In parallel to the control process, a guide was distributed to all companies, to the attention of the skippers. This guide contains instructions derived from Resolution 15/08 and from the ANABAC-OPAGAC agreement. In addition to the guide, skippers follow workshops in which detailed information is given and in which requested additional explanations are given.

2.5 Observation of FAD structure and fauna release – observers training

For the observers, training sessions are being done in the different structures taking part into the observation. These training sessions comprise (1) a general overview of the use of FADs in tuna purse-seine fishery, the related impact on non-targeted fauna and the mitigation measures, (2) instructions on how to identify and describe fauna release operations and FADs through ad-hoc forms, and (3) exercises to train the observers for filling the corresponding forms.

2.6 In-situ observation

The release of sharks, rays, whale sharks and sea turtles is registered through specific forms named B2 (for sharks) and B3 (for whale sharks, rays and turtles), see **Figure 1 and Figure 2**).

These forms refer to the current form B used to describe the characteristics of the fishing set. A specific form (B2) was prepared for sharks only, because they can occur in important amounts in a fishing set. Whale sharks, rays and turtles appear usually in smaller amounts, so they were associated in a same form B3. The forms B2 and B3 register the characteristics of each individual release, through four fields:

- a general field regarding individual characteristics (species, size, and sex if identifiable).

- a field in which the release mode is registered. Five release modes are accepted for sharks in the code of good practices: (1) using the brailer, (2) using light equipment such as stretcher, fabric, sarria or cargo net, (3) using specific equipment such as a hopper or lateral doors, (4) manually from deck or (5) after disentangling. In case of observing a non-conform release (e.g. handling a shark with a rope), the observer ticks the corresponding case and mentions the reason of the non-conformity: RI (residual unavoidable mortality: the animal comes dead, or is not detected and is kept on board, o is detected in lower deck and cannot be handled safely); M (lack of material to handle the animal properly and safely); NC (not complying: good practices are not applied although the conditions allow their application).

- a field to register the time at which an animal is detected and the time at which it is released, so as to measure the amount of time required to release each animal.

- a field to estimate the state of the animal when it is released at sea. If they can be observed, the eyes, the head, the fins, the skin and the gill slits of each released animal are scored P ("perfect", no damage), M ("moderate", moderate damages), S ("severe", important damage with a risk for the animal's survival) or U ("unknown", could not be observed). These elements, together with the release mode and the release time, give an indication on the animal's ability to survive after release.

The form B3 has a similar structure (**Figure 2**), only the release modes and the body parts differ, as they correspond to each group of animals (whale sharks, rays, turtles).

The FADs detailed characteristics are also registered through a specific form named D2 (**Figure 3**) and referring to the actual form D relative to FAD general characteristics. This form D2 registers:

- the material of the FAD, so as to discriminate objects made of wood and vegetable elements from plastic or metallic objects.

- the superior and inferior coverage of the FAD, for which three possibilities are allowed by the code of good practices (non-covered, covered with net whose mesh size is < 3cm, covered with non-meshed material), and one considered entangling (covered with net whose mesh size is > 3cm).

- the subsurface structure, for which three types are allowed by the code of good practices (net gathered in sausages, open net with mesh size is < 3cm, ropes or other non-meshed material) and one considered entangling (open net with mesh size > 3cm).

The presence of single pieces of net in the subsurface part and their mesh size are also registered.

- the presence of other components (plastic containers, corks, etc.).

- the fact of modifying or replacing the raft or the subsurface structure.

3. Results and discussion

3.1 Control of active buoys at sea

The data corresponding to the month of September to December 2015 for the Indian Ocean were received at the beginning of the months of November 2015 to February 2016, respectively. During this period no vessel was reported to have a daily number beyond authorized maximum in the Indian Ocean i.e. 550 buoys (**Figure 4**). We also noticed an important decrease in the fishing effort, with a reduction by 20% of the number of active FADs in the 4th quarter of 2015 (33% since September 10th).

3.2 In-situ observation of good practices in the Atlantic Ocean

We present here results corresponding to data from 160 trips observed on 24 vessels operating in the Atlantic Ocean. FADs structure and fauna release operations were observed on these boats between December 2014 and January 2016. Among these 160 trips, 84,5% of observed FADs had a non-entangling upper side of raft, 79.6% had a non-entangling lower side of rafts, and 80.3% ha d anon-entangling subsurface structure (**Figures 5 and 6**). Overall, the conformity rate was superior to 90% for most vessels.

The cases of non-conformity were due to partial information of skippers. As a matter of example one of the skippers in the Atlantic Ocean believed that the subsurface part should be non-entangling from the surface to 20m depth, and considered that large meshed open nets below 20m were harmless. Another one was using non-entangling raft structures but in order to generate more shade he added some single net pieces with a mesh larger than 3cm. These situations were easily solved through providing more detailed information and advice on FAD design. Another reason of the non-conformity is the necessary period to substitute all old entangling FADs by new non-entangling FADs. This work is still in progress in some regions, which also explains the lower rates of conform FADs observed in some fishing trips. One interesting feature was the progress made by several vessels in which consecutive fishing trips could be observed. This was the case for example for the vessels noted e, i, l, on **Figure 5**.

In the case of by-catch releases, 4759 animals were correctly released along these 160 trips. The global conformity rate of fauna releases was 74%, and reached 100% conformity rate for most species and trips (**Figure 7**). Most rays were released either directly from the purse seine using the brailer or manually from deck. Most sharks and turtles were released manually from deck.

The conformity rates were particularly good for turtles (95%). It was more variable among vessels for mantas and hammerhead sharks, which are usually large individuals. The comparison of the sizes of animals released correctly vs incorrectly (**Figure 8**) shows that the modal size is around 100 cm for animals released correctly, vs 200 cm for animals released non correctly. The size difference between correctly release and incorrectly released animals is significant (**Figure 9**).

These differences are due to a greater difficulty to handle large animals, especially in the vessels not equipped with adequate material and in which most releases are done manually. Recommendations were provided to the ship owners regarding the material (such as tarpaulin, cargo nets etc. associated with a crane) to improve fauna releases in vessels not equipped yet.

In the results we present here, we did not classify yet the non-conform releases into inevitable, due to a lack of material or due to non-compliance. The actual rate of non-conformity due to non-compliance is therefore inferior to the global rate of non-conformity exposed in the present document.

4. Conclusive notes

These first results are overall encouraging regarding good practices: we observed good levels of conformity, and progress was made in the vessels where the conformity levels were initially low. We also observed an important reduction of the number of active FADs in the Indian Ocean in the recent period.

Overall, these results indicate the significant efforts done of the Spanish and associated purse-seine fleet to monitor fishing effort with FADs and mitigate the side effects of FADs.

Table 1. Format specifications for the data transmitted monthly by the buoy manufacturers. For a better understanding of annexes 1 to 4, variable names are also provided in Spanish.

variable	format	example	notes
Date (fecha)	dd-mm-yyyy	17-10-2015	
Time (hora)	hh.mm	12.50	UTC time. Decimal format.
Buoy ID (número de boya)	Following format of each one of the manufacturing companies; individual and non-transferable code.		
Latitude (latitud)	XX.XX	12.80	Degrees North (i.e. degrees South will be negative). Decimal format
Longitude (longitud)	XX.XX	40.75	Degrees East. Decimal format
Speed (velocidad)	XX.XX	0.5	Speed in knots

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Verification of Good Practices ANABAC/OPAGAC

RELEASE OF ASSOCIATED FAUNA

Form **B2**
version 2015

fishing set nº:
Date:
fishing trip code
route form nº:
route line nº:
fauna liberation form nº:

strapping start time: h h m m

Released fauna - sharks (1 line by individual, see example)

	individual			release mode							time		(4) state of the animal				
	(1) species	(2) size	(3) sex	using brailer	by stretcher, fabric, sarria, cargo net	with specific equipment	manual from deck	after disentangling	non conform	reason of non conformity (6)	animal detected	animal released	eyes	head	fins	skin	gill slits
0	FAL	140	2					1			7:35	7:47	P	P	M	M	P
1																	
2																	
3																	
4																	
5																	
6																	
7																	
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30																	

Notes (5):

(1) put species code - see usual observers handbook. (2) in centimeters

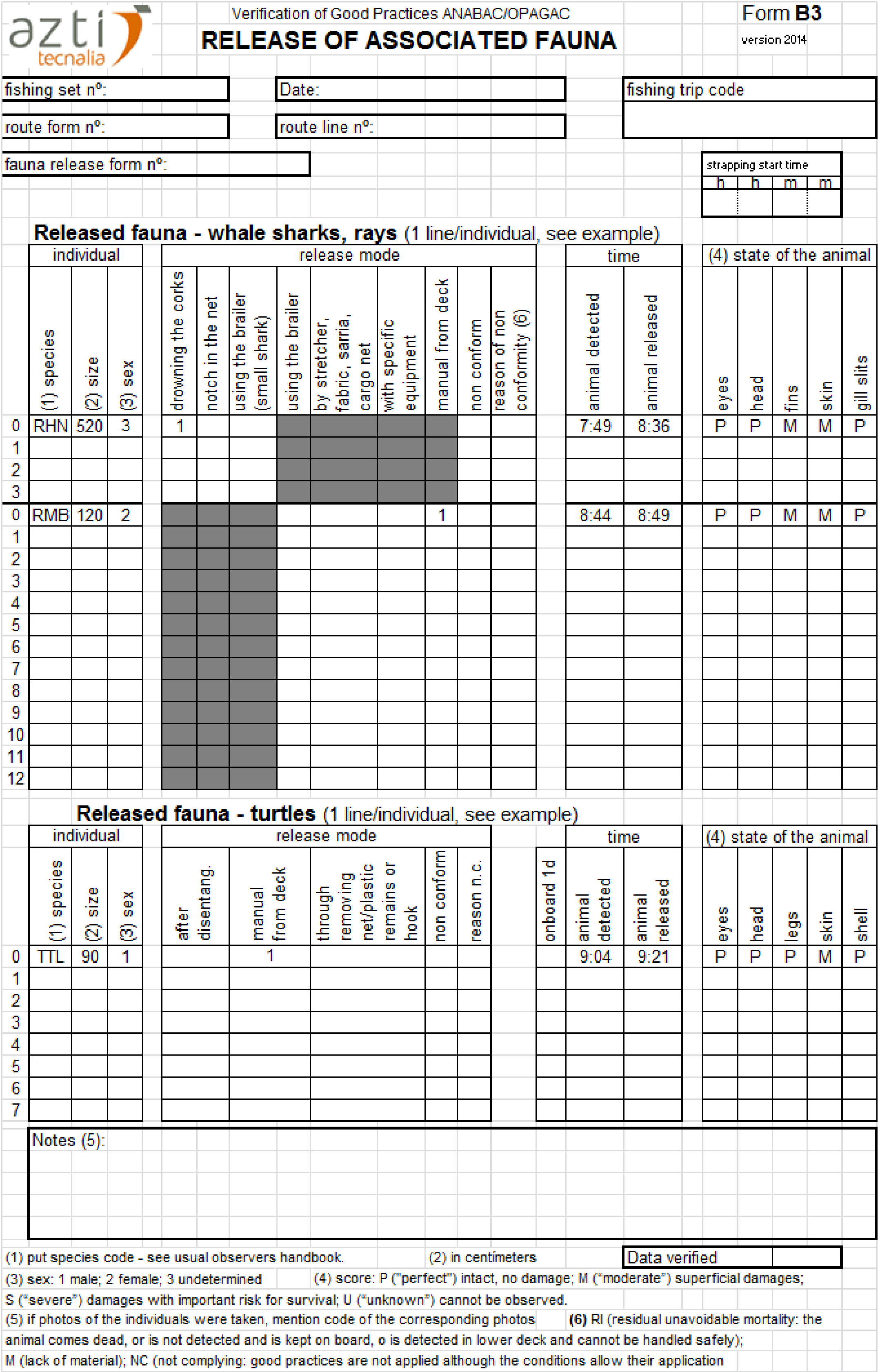
Data verified

(3) sex: 1 male; 2 female; 3 undetermined (4) score: P ("perfect") intact, no damage; M ("moderate") superficial damages; S ("severe") damages with important risk for survival; U ("unknown") cannot be observed.

(5) if photos of the individuals were taken, mention code of the corresponding photos **(6)** RI (residual unavoidable mortality: the animal comes dead, or is not detected and is kept on board, o is detected in lower deck and cannot be handled safely); M (lack of material); NC (not complying: good practices are not applied although the conditions allow their application

If more than 30 individuals are released, continue on a new form

Figure 1. Form B2 used to register the information of shark releases.



Verification of Good Practices ANABAC/OPAGAC

RELEASE OF ASSOCIATED FAUNA

Form **B3**
version 2014

fishing set nº: | Date: | fishing trip code

route form nº: | route line nº:

fauna release form nº:

strapping start time: h h m m

Released fauna - whale sharks, rays (1 line/individual, see example)

	individual			release mode									time		(4) state of the animal				
	(1) species	(2) size	(3) sex	drowning the corks	notch in the net	using the brailer (small shark)	using the brailer	by stretcher, fabric, sarria, cargo net	with specific equipment	manual from deck	non conform	reason of non conformity (6)	animal detected	animal released	eyes	head	fins	skin	gill slits
0	RHN	520	3	1									7:49	8:36	P	P	M	M	P
1																			
2																			
3																			
0	RMB	120	2							1			8:44	8:49	P	P	M	M	P
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			

Released fauna - turtles (1 line/individual, see example)

	individual			release mode						time		(4) state of the animal				
	(1) species	(2) size	(3) sex	after disentang.	manual from deck	through removing net/plastic remains or hook	non conform	reason n.c.	onboard 1d	animal detected	animal released	eyes	head	legs	skin	shell
0	TTL	90	1		1					9:04	9:21	P	P	P	M	P
1																
2																
3																
4																
5																
6																
7																

Notes (5):

(1) put species code - see usual observers handbook. (2) in centimeters

Data verified

(3) sex: 1 male; 2 female; 3 undetermined (4) score: P ("perfect") intact, no damage; M ("moderate") superficial damages; S ("severe") damages with important risk for survival; U ("unknown") cannot be observed.

(5) if photos of the individuals were taken, mention code of the corresponding photos **(6)** RI (residual unavoidable mortality: the animal comes dead, or is not detected and is kept on board, o is detected in lower deck and cannot be handled safely); M (lack of material); NC (not complying: good practices are not applied although the conditions allow their application

Figure 2. Form B3 used to register the information of whale sharks, rays and turtle releases.

Verification of Good Practices ANABAC/OPAGAC

Form D2

1 line by FAD if no modification, 2 lines by FAD if modification (state when arriving and state when leaving)

BOAT name: **Fishing trip start date:**

OBSERVER: **Fishing trip code:**

					RAFT														SUBSURFACE STRUCTURE											OTHER COMPONENTS					
							Superior coverage					Inferior coverage							net in sausage		open net		single net pieces												
							Net					Net																							
Nº Form D	**when arriving**	**when leaving**	**DATE**	**TIME**	Canes / Vegetal	Metallic or PVC	≤ 3cm	> 3cm	cov. without net	non covered	not visible	≤ 3cm	> 3cm	cov. without net	non covered	not visible	**they modify it**	**they replace it**	≤ 3cm	> 3cm	≤ 3cm	> 3cm	≤ 3cm	> 3cm	**rope / no mesh**	not visible	without tail	**they modify it**	**tey replace it**	plastic containers	Corks	Bags	Palms, canes...	Color belts	weights
45	*X*		*14/03/2014*	*13:22*	*X*		*X*			*X*							*X*		*X*														*X*		
45		*X*	*14/03/2014*	*13:22*	*X*						*X*	*X*							*X*														*X*		

Figure 3. Form D2 used to register the characteristics of FADs and to determine their entangling or non-entangling nature.

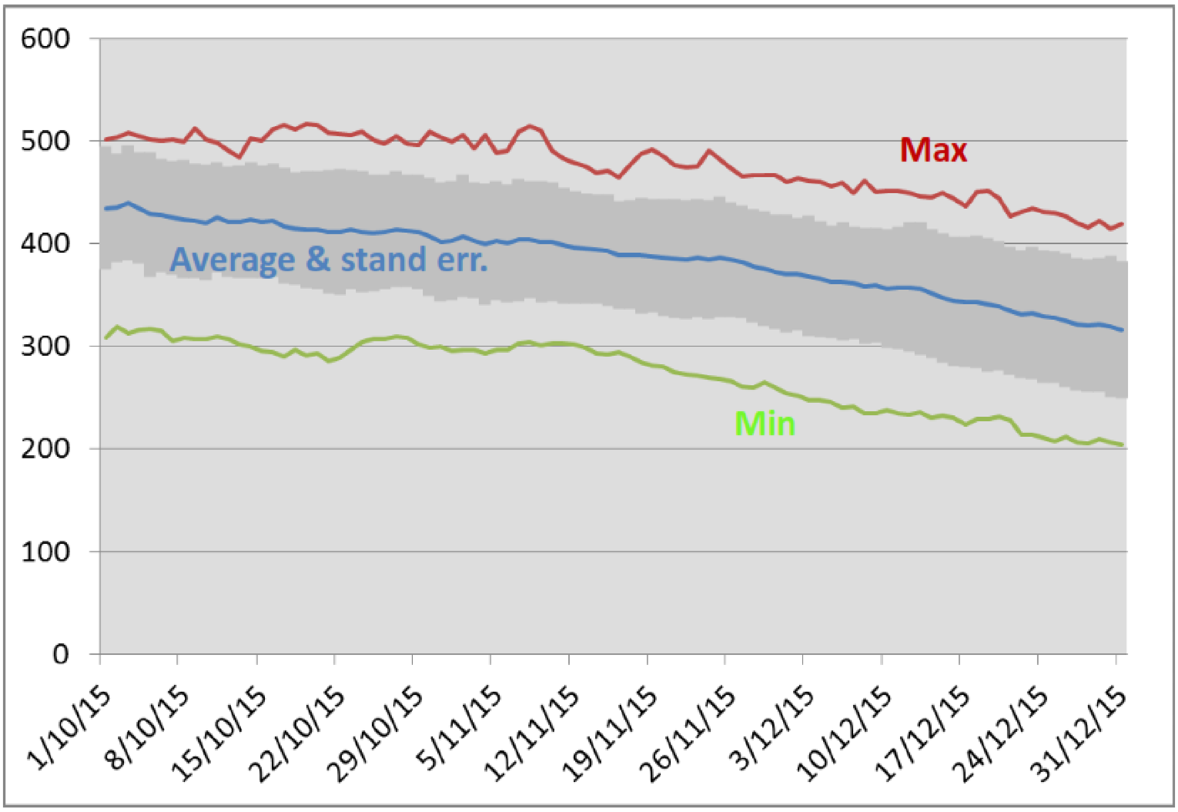


Figure 4. Evolution of the number of active FADs by purse-seiner in the Indian Ocean.

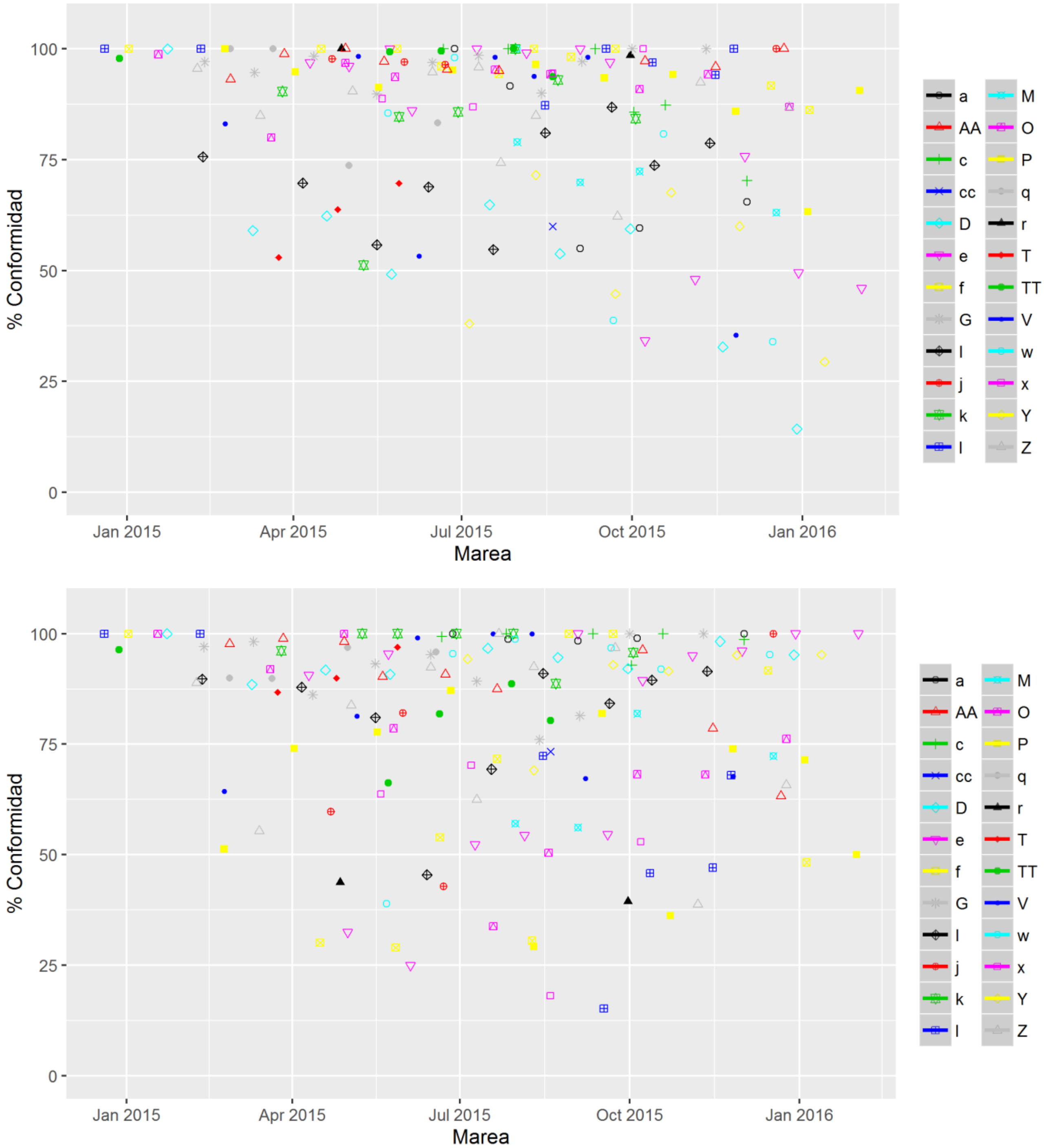


Figure 5. Percent of conform rafts (upper panel: upper side of raft; lower panel: lower side of raft) observed on FADs used by each of 160 fishing trips surveyed in the Atlantic Ocean. Letters in the legend correspond to vessels.

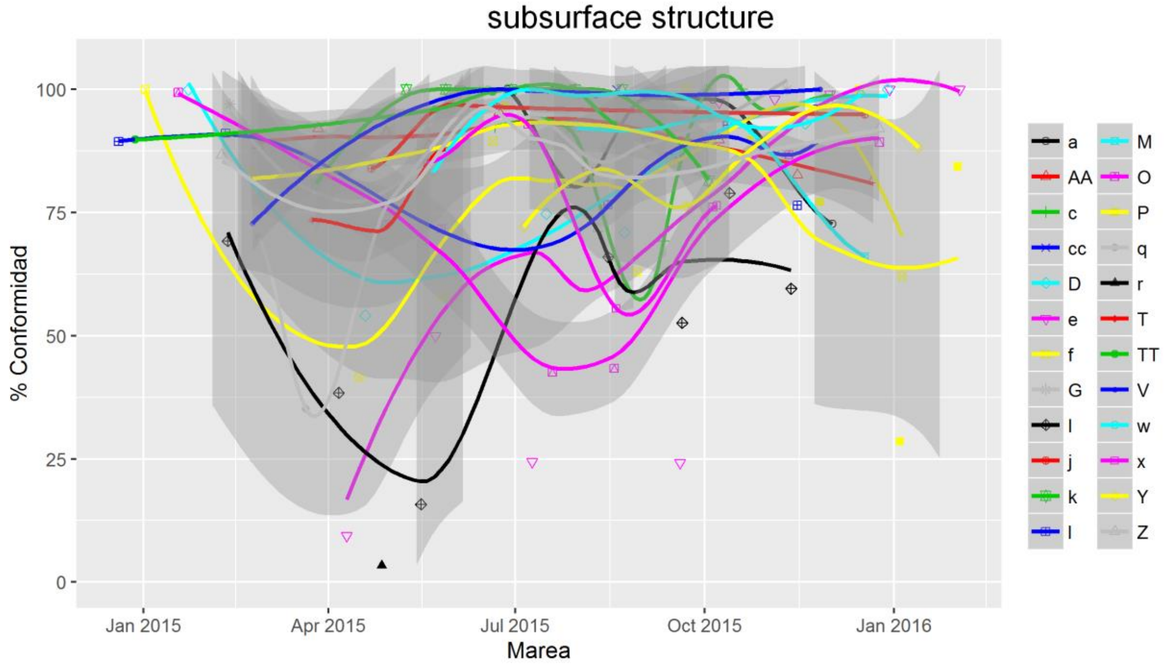


Figure 6. Percent of conform subsurface structures observed on FADs used by each of the 160 fishing trips surveyed in the Atlantic Ocean. Letters in the legend correspond to vessels.

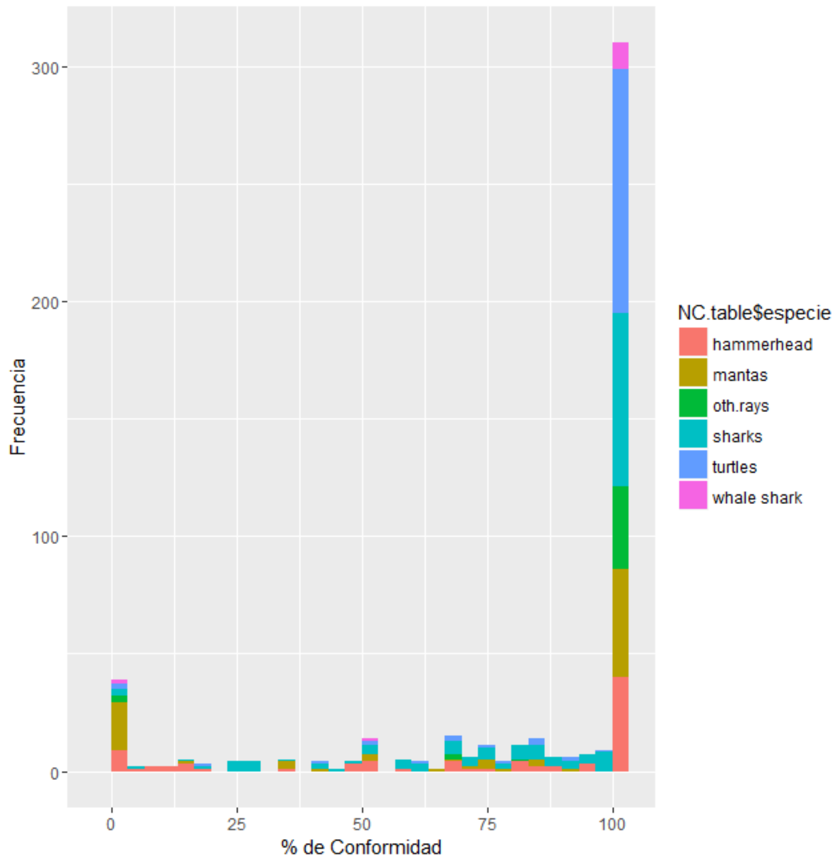


Figure 7. percentage of conform fauna releases by species group (hammerhead sharks, sharks, manta rays, rays, turtles, whale sharks) and fishing trips surveyed, for each of the 160 fishing trips surveyed in the Atlantic Ocean.

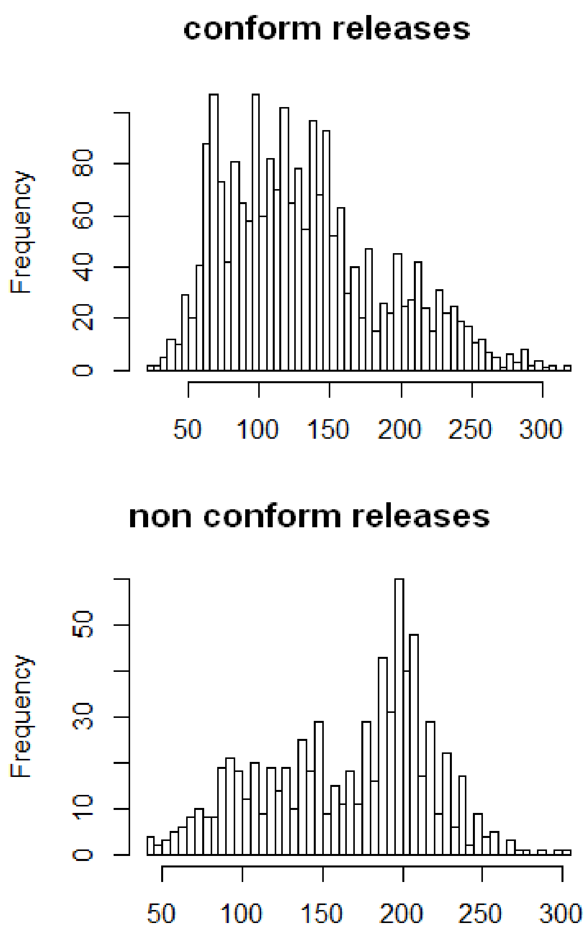


Figure 8. Size distribution of the animals released correctly (left panel) vs incorrectly (right panel) during the 160 fishing trips surveyed in the Atlantic Ocean.

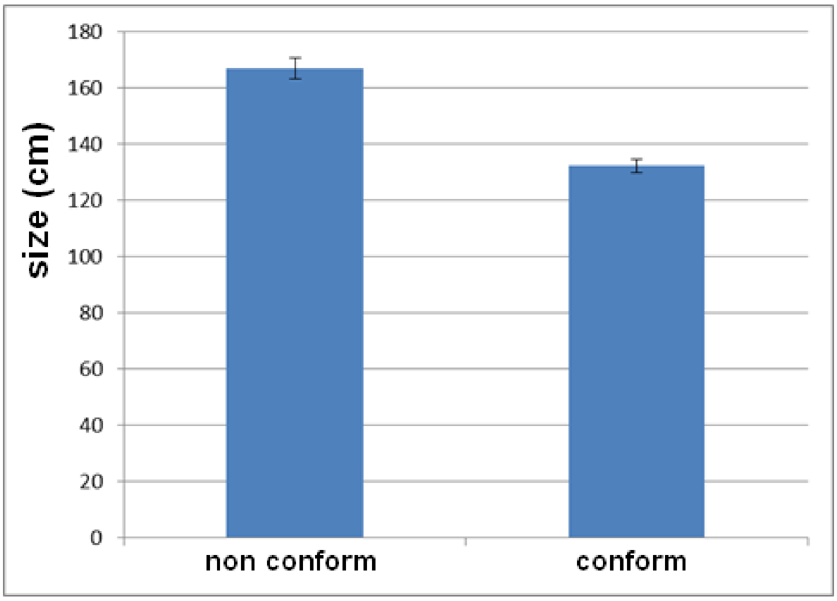


Figure 9. Size (mean and standard deviation) of the animals released incorrectly vs correctly during the 160 fishing trips surveyed in the Atlantic Ocean.

Annex 1

R SCRIPT TO CONTROL NUMBER OF ACTIVE BUOYS AT SEA – DATA PREPARATION

```
# Preparation
# Import_multiple_csv_files_to_R
# Modify the files as needed and save as a unique csv file
# save as a unique .csv file

# Part 1
# Purpose: Account total number of buoys

# Part 2
# Purpose: Account total number of buoys at sea (excluding those on board of vessels and on land)

# Part 3
# Purpose: Account number of active buoys at the sea each day
##################################################################################
# Notes:
# save all .csv files in the working directory #######
# Be careful-> dont add any .csv file in this directory #######
# Things to change:
# setwd (line 28)
# write.table (line 51 and 59) -> create a new directory different from the wd
# n (line 78 -> to choose boat)

################################################################
# Current wWorking directory
setwd("C:/use/username/control_buoys/data_boya")

# Run script to read all csv files in the current directory
source("../import_files.r")

# import csv files
csv.import<-import.multiple.csv.files("C:/use/username/control_buoys/data_boya",".csv$",sep=",")

###################################################################################
# Modify the files as needed and save as a unique csv file
# Add a new column with the ship ID
for (i in 1:length(csv.import))
{
  csv.import[i]<- mapply(cbind, csv.import[i], "ShipID"=list.filenames[i], SIMPLIFY=F)
}

# Remember to change the filename
write.table(csv.import[1],file="../multiple/multiplecsv_september.csv",sep=",",
        col.names=c("Fecha","Hora","Numero.de.boya","Latitud","Longitud","Velocidad","ID"),
        row.names=F)

for (i in 2:length(csv.import))
{
```

```
write.table(csv.import[i],file="../multiple/multiplecsv_september.csv",sep=",",row.names=F,append=T,col.name
s=F)
}

# save it to the folder with your custom functions
save(import.multiple.csv.files,file="C:/use/username/control_buoys/import.multiple.csv.files.RData")

#############################################################################################
# load it like this whenever you need it in another script with
load("C:/use/username/control_buoys/import.multiple.csv.files.RData")

data_september<-read.table("../multiple/multiplecsv_september.csv",sep=",",header=TRUE)
############################################################################################
# Part 1
# Choose the boat to be analyzed (n=1:25)
# Details on boatID on script part1.r

n=7

# Run Part 1
source("../part1.r")
###########################################################################################
# Part 2
source("../part2.r")

###########################################################################################
# Part 3
source("../part3.r")
```

Annex 2

R SCRIPT TO CONTROL NUMBER OF ACTIVE BUOYS AT SEA – PART 1: VESSEL SELECTION AND COUNTING TOTAL NUMBER OF ACTIVE BUOYS

```
# control buoys -> Part 1
# Purpose: Account total number of buoys

#Select only one vessel

# Boat IDs
boat_ID=0
boat_ID[1]= 7325904
boat_ID[2]= 8208531
boat_ID[3]= 8719334
boat_ID[4]= 8906468
boat_ID[5]= 9046966
boat_ID[6]= 9127435
boat_ID[7]= 9130779
boat_ID[8]= 9176917
boat_ID[9]= 9196682
boat_ID[10]= 9202144
boat_ID[11]= 9202704
boat_ID[12]= 9228162
boat_ID[13]= 9281308
boat_ID[14]= 9281310
boat_ID[15]= 9286724
boat_ID[16]= 9292785
boat_ID[17]= 9335226
boat_ID[18]= 9335745
boat_ID[19]= 9383156
boat_ID[20]= 9663154
boat_ID[21]= 9663166
boat_ID[22]= 9684500
boat_ID[23]= 9702869
boat_ID[24]= 9733478
boat_ID[25]= 9733480

# Choose the boat to be analyzed (can be selected manually)
# n=9
 boat_ID[n]
septemberSubset <- data_september[grep(boat_ID[n], data_september$ID), ]

cat("Boat ID:",boat_ID[n],"\n")
total_buoys<- length(levels(septemberSubset$Numero.de.boya))
cat("The total number of active buoys is:",total_buoys,"\n",
    "If this number is smaller than 550 stop here")

#If total_buoys < 550 stop here
# end of Part 1
#########################################################################
##########################################################################
```

Annex 3

R SCRIPT TO CONTROL NUMBER OF ACTIVE BUOYS AT SEA – PART 2: COUNTING TOTAL NUMBER OF ACTIVE BUOYS AT SEA

```
# control buoys -> Part 2
# Purpose: Account total number of buoys at the sea (excluding those on board of vessels and on land)

#Account number of buoys on board of the vessel, on land and with no information.
VesselName_september_boat<-subset(septemberSubset, Velocidad>=6.01)
B<-length(unique(VesselName_september_boat$Numero.de.boya))# Buoys on board of the vessel

VesselName_september_land<-subset(septemberSubset, Velocidad<=0.01)
L<-length(unique(VesselName_september_land$Numero.de.boya))# Buoys on land

cat("Boat ID:",boat_ID[n],"\n")
cat("The number of buoys on board  is:",B,"\n",
    "The number of buoys on land is:",L,"\n",

#Total number of active buoys at the sea

# Merge buoys on land and buoys on board of vessel
NN1<-merge(VesselName_september_boat,VesselName_september_land,all=L) # boat & land
number_buoys_sea<- total_buoys  - NN1

#cat("Boat ID:",boat_ID[n])
cat("The total number of buoys at the sea from boat X is:",number_buoys_sea,"\n",
    "If this number is smaller than 550 stop here")

# end of Part 2
##############################################################################
```

Annex 4

R SCRIPT TO CONTROL NUMBER OF ACTIVE BUOYS AT SEA – PART 3: COUNTING TOTAL NUMBER OF ACTIVE BUOYS AT SEA EACH DAY

```
# control buoys -> Part 3
# Purpose: Account number of active buoys at the sea each day

# Check if there are more than 550 active buoys on a given day

buoys_at_sea <- septemberSubset[septemberSubset$Velocidad<=6 & septemberSubset$Velocidad>=0.01,]

dia1 <- buoys_at_sea[buoys_at_sea$Fecha=="2015-09-01",]

cat("Boat ID:",boat_ID[n])
for (i in 1:30)
{
dia <- buoys_at_sea[buoys_at_sea$Fecha==buoys_at_sea$Fecha[i],]
number<-length(unique(dia$Numero.de.boya))
  cat(sprintf("The number of actibe buoys on day \"%s\"",buoys_at_sea$Fecha[i],"is:"),
      sprintf("is:\"%s\"\n", number ))
}
```