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# Verification of the limitation of the number of FADs and best practices to reduce their impact on bycatch fauna

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## Summary

This document presents the verification of two initiatives for a better monitoring of FADs and of their effects: the limitation of the number of FADs used in the Indian Ocean (following resolution 15/08) and the application of good practices to reduce the mortality of FAD-associated fauna. Both initiatives are being verified for the Spanish tuna purse-seiner organizations ANABAC and OPAGAC. These organizations established in 2012 a common agreement for the application of good practices aiming at reducing the mortality by entangling or by incidental catch of FAD-associated sensible species (elasmobranchs and turtles) and a common agreement in 2015 for the limitation of the number of FADs, in addition to Resolution 15/08.

In order to monitor the limitation of the number of FADs used and the level of application of these good practices, systems of verification are being implanted for the vessels of ANABAC and OPAGAC operating in the Indian Ocean – in the case of the control of the number of FADs – and for all their vessels in the case of the application of good practices. This verification is based on data transmission by buoy manufacturers and data processing through R, and on in-situ registration of the good practices by observers.

The training for skippers and observers, as well as the first data of good practices observed in the Atlantic and Indian Ocean are also presented. These first results are overall encouraging, with a majority of vessels displaying a level of compliance superior to 80% for non-entangling FADs and reaching 100% for fauna release operations. In the case of boats with lower levels of compliance, significant progress could be observed in consecutive fishing trips.

**Key-words**: effort control, buoys, non-entangling FADs, bycatch 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, bycatch).

Through the adoption of Resolution 15/08 by the Indian Ocean Tuna Commission, the maximum number of instrumented buoys active at sea at any one time in relation to each purse seine vessel is set at 550, and the maximum number of instrumented buoys that may be acquired annually by each fishing vessel is set at 1100. In addition to Resolution 15/08, Spanish purse seiner organizations

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ANABAC and OPAGAC established 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 applies 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 IOTC area of competence. This Resolution 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. Other buoys, such as radio buoys used on DFADs, not meeting this definition, shall be gradually phased out by the 1st January 2017. 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 transmiting. 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 will be sent monthly and individually (per vessel), and will include all records of active buoys corresponding to each purse seine vessel in the concerned month. The files will be sent with one month lag from the last day of activities included therein; that is, the information of the month of October 2015 will be sent on December 1st 2015. The name of each file will be: 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.

**Table1**: 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 |

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 active 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, the processing stops at the end of this second part. In case we will observe a vessel with more than 550 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 will be done by the fisheries office in Seychelles when it will be installed.

### 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 fig. 1 and fig. 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…)
- the fact of modifying or replacing the raft or the subsurface structure.

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# 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 | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | | | |
| 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: |
| route form nº: | route line nº: |
| fauna release form nº: | fishing trip code |

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):

Data verified

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

(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.

**Form D2**

Verification of Good Practices ANABAC/OPAGAC

**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:**

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

## 3. Results and discussion

### 3.1. Control of active buoys at sea

The data corresponding to the month of September will be received at the beginning of November, their processing will therefore start in November. In function of the characteristics of the data received, adjustments of the methodology will be done.

### 3.2. In-situ observation of good practices in the Atlantic and Indian Ocean

We present here preliminary results corresponding to data from 19 vessels operating in the Atlantic Ocean and 6 operating in the Indian Ocean. FADs structure and fauna release operations were observed on these boats between December 2014 and July 2015. Among the 6 vessels observed in the Indian Ocean, the use of FADs with non-entangling raft was superior to 90% in 60% of the fishing trips observed, and the use of FADs with non-entangling submersed part was superior to 90% in 60% of the fishing trips. Among the 19 boats observed in the Atlantic Ocean, the use of FADs with non-entangling raft was superior to 80% in 59% of the fishing trips observed, and the use of FADs with non-entangling submersed part was superior to 80% in half of the fishing trips (Figures 5 and 6).

The cases of non-conformity were due to partial information of skippers. As a matter of example one of the skippers in the Atnaltic 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 in the Indian Ocean (vessel a, figure 5) was using non-entangling raft structures but added some single net pieces with a mesh larger than 3cm. These situations are 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 areas.

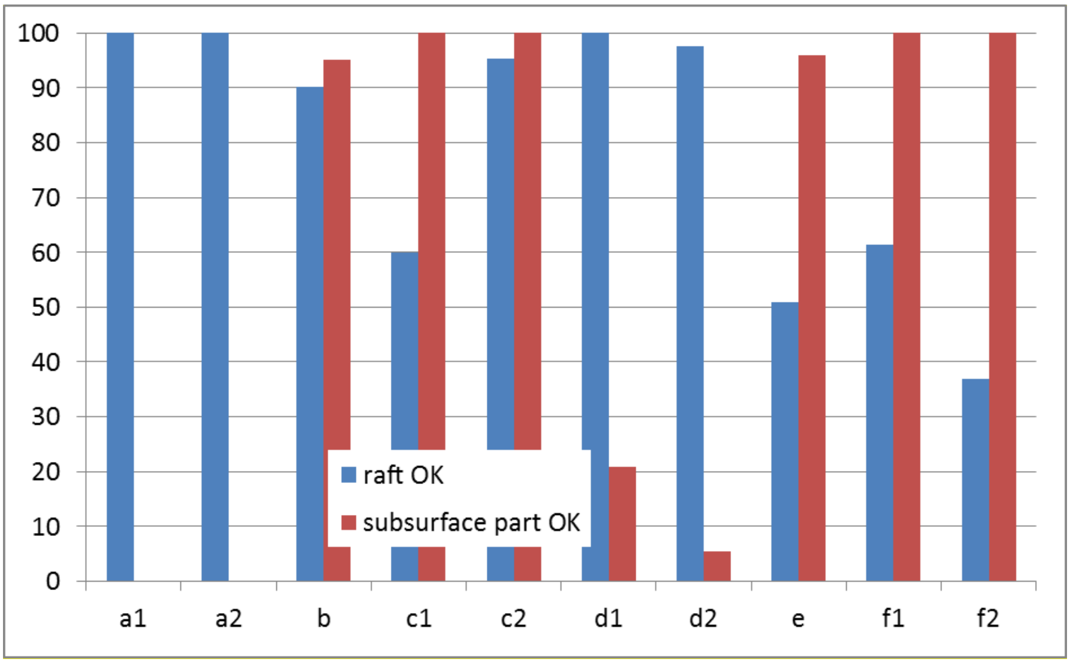


**Figure 5**: percent of conform rafts and subsurface parts observed on FADs used by each of 10 fishing trips surveyed in the Indian Ocean. Letters in the x-axis correspond to vessels, associated numbers correspond to consecutive trips observed on the vessel

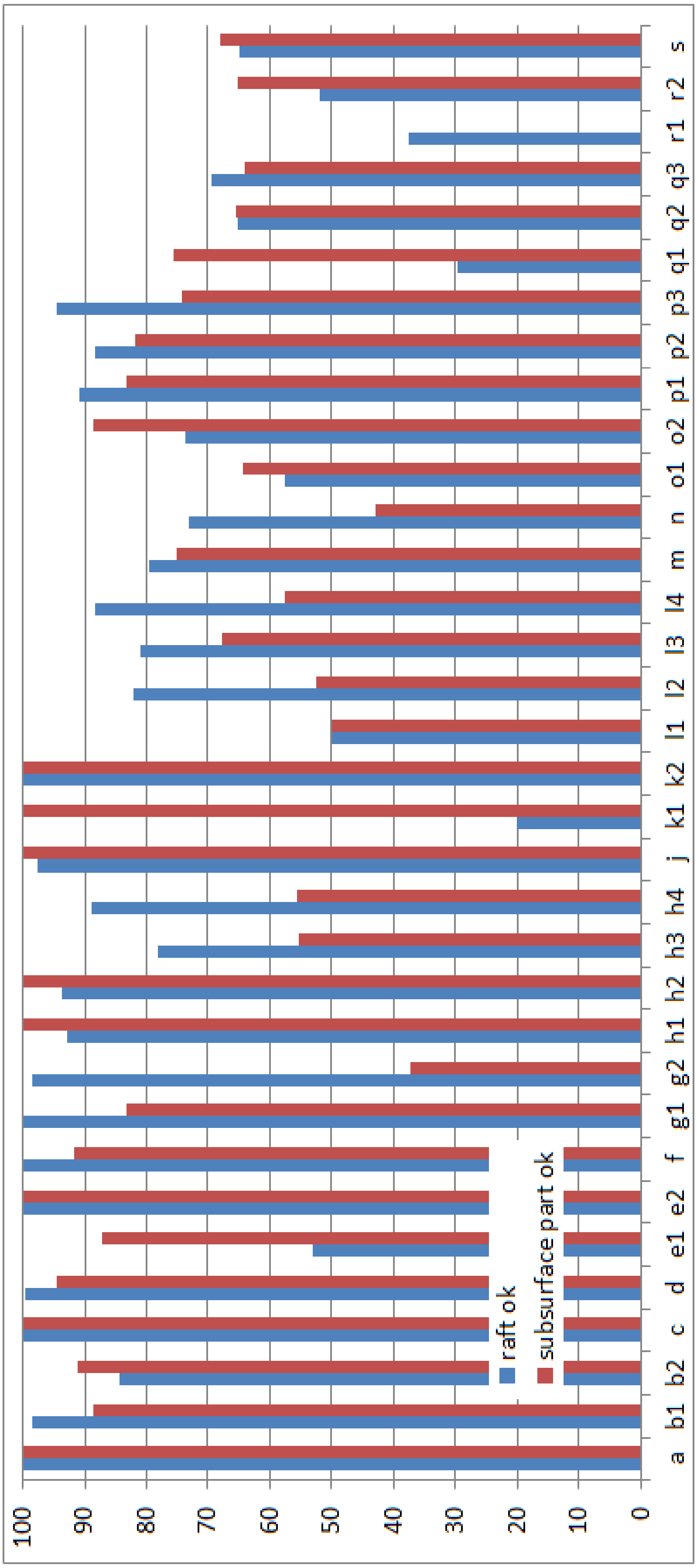


**Figure 6**: percent of conform rafts and subsurface parts observed on FADs used by each of 34 fishing trips surveyed in the Atlantic Ocean. Letters in the x-axis correspond to vessels, associated numbers correspond to consecutive trips observed on the vessel

One interesting feature was the progress made by several vessels in which consecutive fishing trips could be observed. This was the case for 6 vessels noted e, k, l, o, q and r on figure 6. In several of them the progresses between two consecutive trips were dramatic, for example for vessels e, k and r (fig. 6).

In the case of by-catch releases, the rate of conform release for sharks and rays was superior to 90% for most vessels in the Atlantic and Indian Ocean (Figure 7 to 9). In the case of sharks the operations were 100% conform in 15 of 25 trips in the Atlantic Ocean (Figure 7) and over 95% conform in 5 of 9 trips in the Indian Ocean (Figure 8). For rays, releases were 100% conform in 11 of 19 trips (Figure 9).

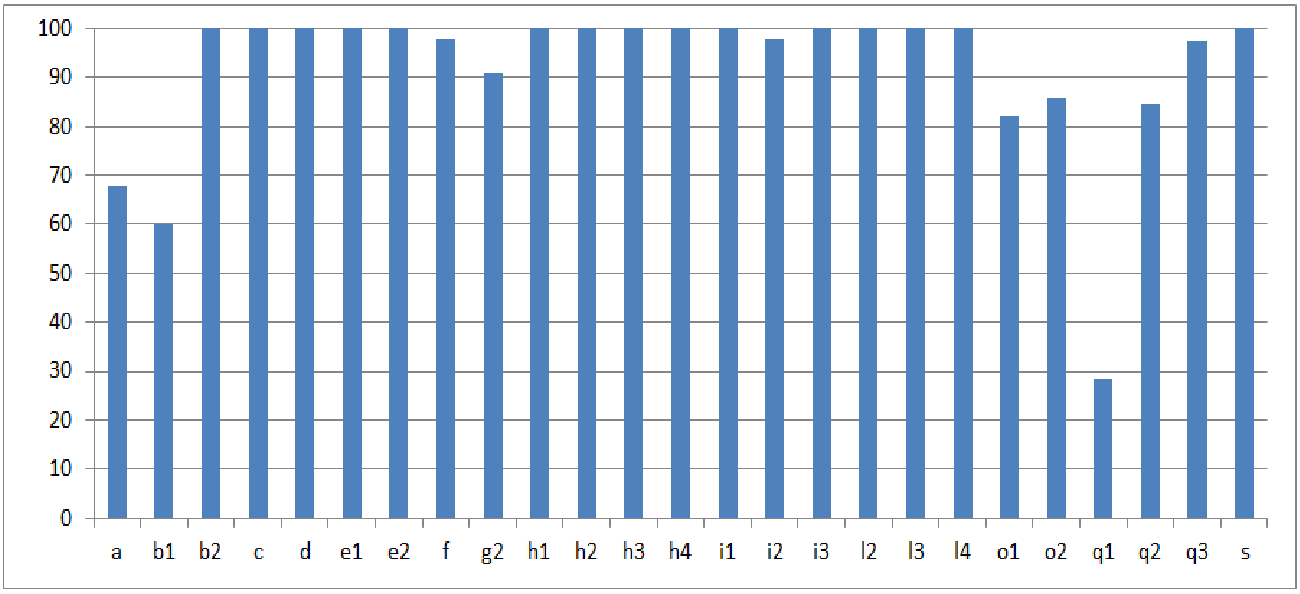


**Figure 7**: percentage of conform shark releases on the fishing trips surveyed in which sharks were bycaught in the Atlantic Ocean. See Fig.5 for x-axis labels.

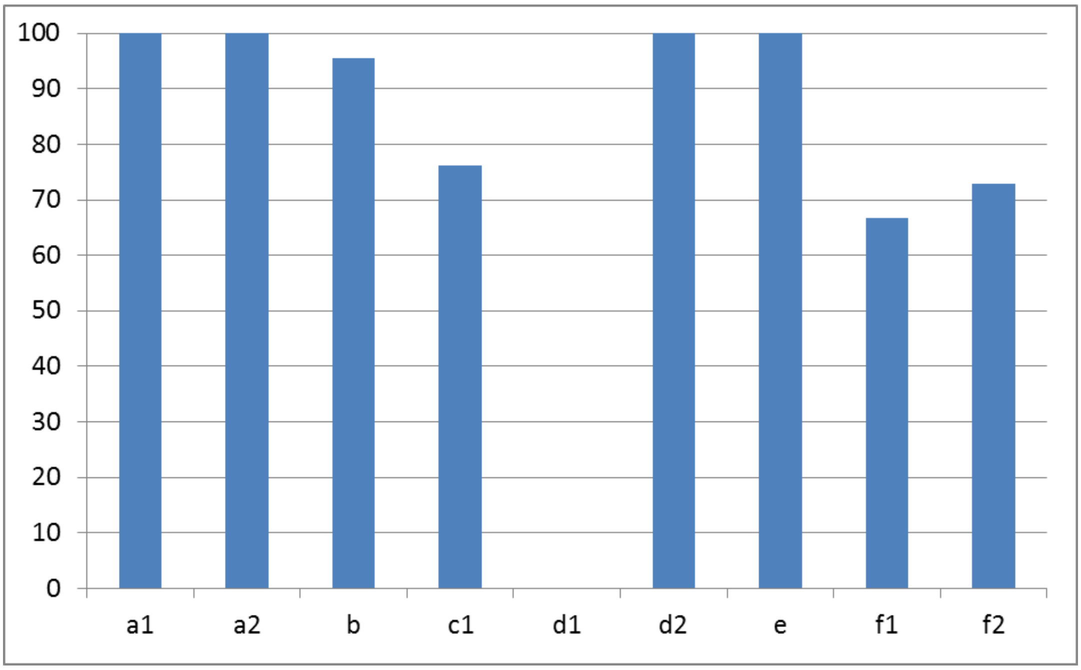


**Figure 8**: percentage of conform shark releases on the fishing trips surveyed in which sharks were bycaught in the Indian Ocean. See Fig.5 for x-axis labels.

In the case of sharks, similarly to the progresses made for FAD structure, we could observe progresses between consecutive trips of a same vessel, through improvement of shark detections and handling.

This was the case for vessels noted b, o and q. In the case of rays, the most dramatic progress was made by vessel q shifting from 0 to 100% of correct releases from one trip to the next one (Figure 9).

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.

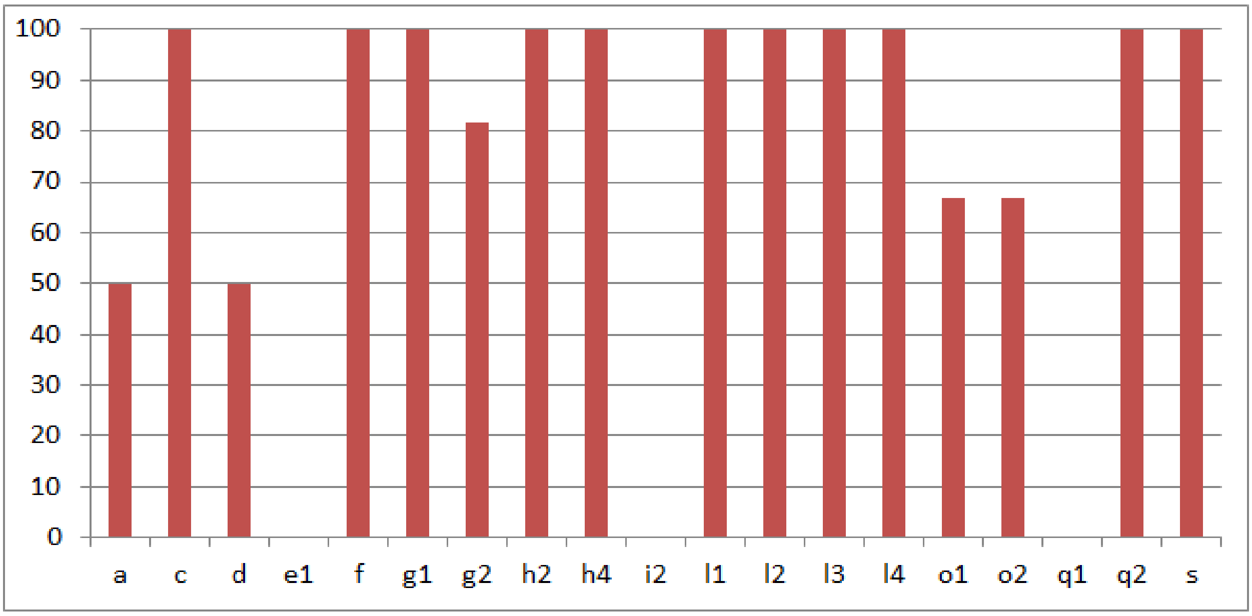


**Figure 9**: percentage of conform ray releases from each of the nine vessels surveyed in which rays were bycaught. See Fig.5 for x-axis labels.

An important feature to take into account in the case of rays is the size of the animals. The lower correct release rates observed were due to a lack of material, which made the manual release of large rays (frequently over 250 cm) unsafe for the crew when the animal was detected on deck and could not be released earlier. Improvements are expected from the installation of adequate material for ray release (such as tarpaulin, cargo nets etc. associated with a crane).

We also need to take into account that the overall number of rays released in the totality of the surveyed vessels was low (n=60) and that correct release rates when considered by individual vessel are based on a very low number on individuals. In particular, the three cases in which the correct release rates were 0% correspond to either one or two individuals, whereas the fishing trip with the highest number of rays observed (n=7) had a correct release rate of 100%. The overall rate of correct release for rays is 78.63%. Similarly for sharks in the Indian Ocean, the 0% rate for vessel d in the first trip observed corresponds to one individual only.

For turtles, the operations observed so far were 100% conform in 20 of 21 fishing trips in which turtles were bycaught (figure 10) and 92.3% in the remaining one.

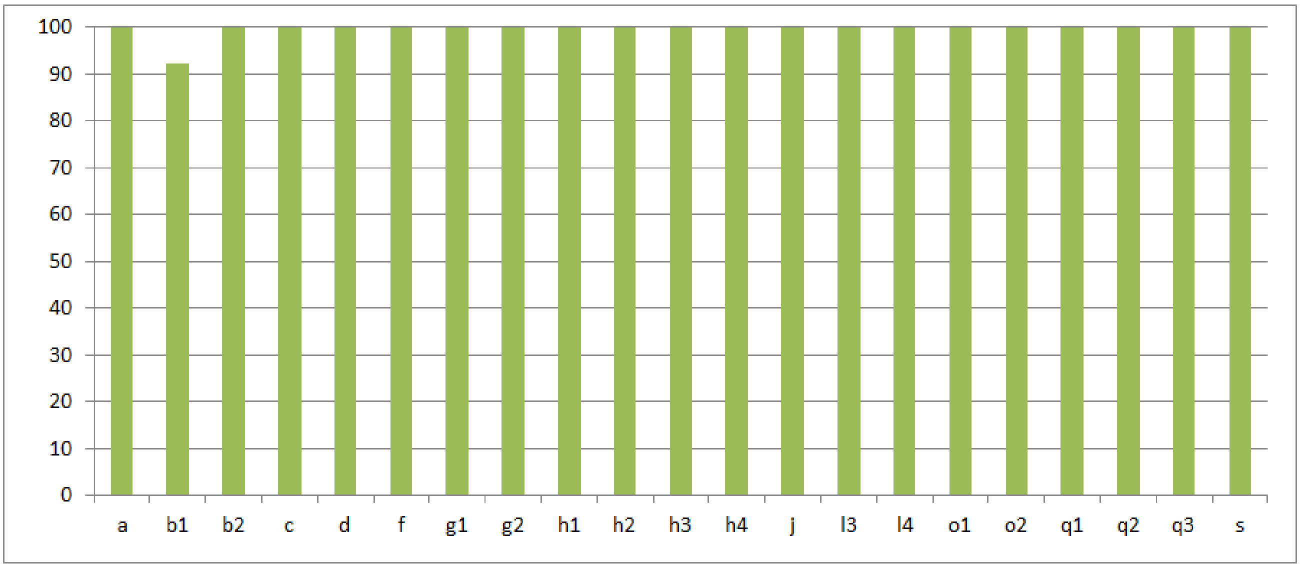


**Figure 10**: percentage of conform turtle releases on each of the fishing trips surveyed in which turtles were bycaught. See Fig.5 for x-axis labels.

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 registered release time was overall short (figure 11). 75% of sharks were released in the first five minutes after detection (59% after three minutes); more than 65% of rays were released in the first five minutes after detection and 87% of turtles were released in the first four minutes (34% in the first minute).

These first results are overall encouraging, on the one hand in terms of correct fauna release operations (reaching high percentages in most vessels) and on the other hand in terms of progresses made by individual vessels during consecutive fishing trips. We expect similar results in the Eastern Pacific Ocean where the observation started later, and we expect a full conformity of both FADs and release operations in the short term.

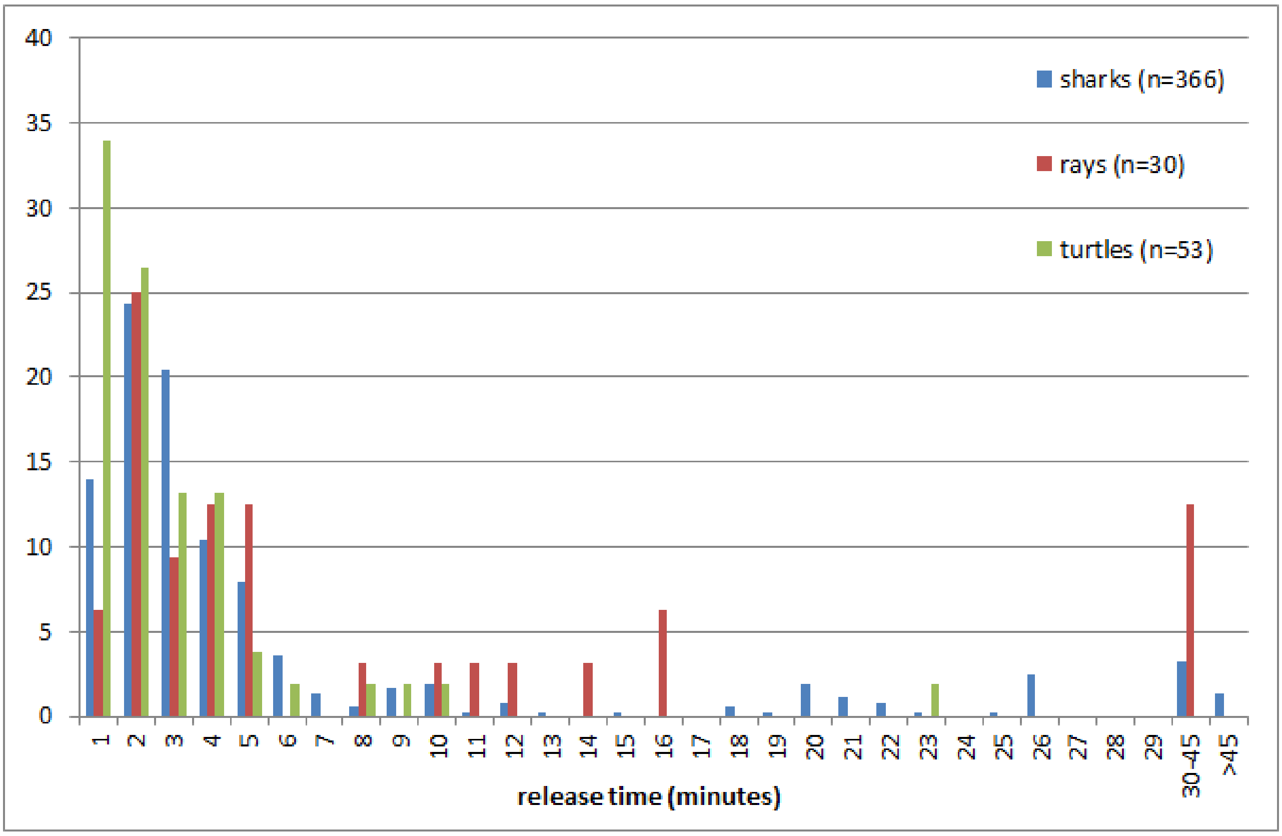


**Figure 9**: distribution of the release time of sharks (blue bars), rays (red bars) and turtles (green bars) from 9 purse seiners in the Atlantic Ocean between December 2014 and March 2015.

## 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.names
=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     #Albacora cuatro
boat_ID[2]= 8208531     #Txoriaundi
boat_ID[3]= 8719334     #Campo libre Alai
boat_ID[4]= 8906468     #Albacan
boat_ID[5]= 9046966     #Elai Alai
boat_ID[6]= 9127435     #Albacora uno
boat_ID[7]= 9130779     #Doniene
boat_ID[8]= 9176917     #Playa de Anzoras
boat_ID[9]= 9196682     #Txori toki
boat_ID[10]= 9202144    #Artza
boat_ID[11]= 9202704    #Intertuna tres
```

```
boat_ID[12]= 9228162    #Playa de Aritzatxu
boat_ID[13]= 9281308    #Albatun dos
boat_ID[14]= 9281310    #Albatun tres
boat_ID[15]= 9286724    #Txori argi
boat_ID[16]= 9292785    #Izurdia
boat_ID[17]= 9335226    #Draco
boat_ID[18]= 9335745    #Alakrana
boat_ID[19]= 9383156    #Txori gorri
boat_ID[20]= 9663154    #Galerna II
boat_ID[21]= 9663166    #Galerna III
boat_ID[22]= 9684500    #Izaro
boat_ID[23]= 9702869    #Itsas Txori
boat_ID[24]= 9733478    #Jai Alai
boat_ID[25]= 9733480    #Euskadi Alai

# 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 ))
}
```