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Study of Alternative Models of Artificial Floating Objects for Tuna Fishery (Experimental Purse-seine Campaign in the Indian Ocean)

by
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1. INTRODUCTION

The target species of Spanish tuna purse-seiners are Tropical tuna: yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*), the secondary species being bigeye (*Thunnus obesus*). The fleet operates in the intertropical waters of the three oceans. Catches are obtained through two types of fishing: associated with artificial floating objects and over free schools. Catches obtained with both types of sets are composed of the same species. However, specific composition is different, since sets over floating objects deliver more important bigeye catches than over free schools; sizes are also different, as are catch volume and the type and number of species that constitute the accompanying fauna.

Since the beginning of large-scale fishing over artificial floating objects, the type of objects used has not varied substantially (not so their detection systems and the type of locator carried by the objects). Although fishing over floating objects has increased purse-seiner efficiency and, subsequently, the catches (fundamentally of skipjack), the large-scale use of objects has produced effects on the fishery that were not habitual before their introduction. Such effects are catches of numerous accessory species (especially in certain time-space strata), including sharks, turtles and other fish species—none of them usable species in this kind of purse-seine fisheries.

In 2005, a Pilot Fishery Action was undertaken in the Indian Ocean, which was presented to the Spanish Fisheries Administration by the shipowners' company ALBACORA, S.A., financed by the aforementioned Administration, and followed up by the Spanish Oceanographic Institute (IEO). One of its main objectives was to further improvements to this mode of fishing where impact on stocks of sensitive species and the ecosystem was concerned. To this end, experiments have involved various prototypes of artificial floating objects and their behaviour, with a view to finding a typology that would result in fewer accessory catches (with particular emphasis on excluding entangled sea turtles), without reducing catches of target species. The design for this Pilot Action was presented at the Indian Ocean Tuna Commission's first session of the working party on bycatch, held in Phuket (Thailand), in 2005.

2. MATERIAL AND METHODS

Data collection was carried out over six months, between 15 May and 15 November 2005, and the working area was the western Indian Ocean.

2.1. Vessels

Work was undertaken on two Spanish tuna purse-seiners and two support vessels, whose characteristics are presented in Table 1.

2.2. General data

Observers were supplied with the forms required for gathering information about the vessels' general activity and environmental conditions, as well as set characteristics, size sampling of the various species and object characteristics.
At each set, observers estimated accessory catches, undertook random size sampling of the commercial catch and collected samples of accessory species, giving priority to turtles, followed, in this order, by sharks, swordfish and other fish.

Furthermore, the purse-seiner was equipped with a depth and temperature sensor, in order to determine the depth reached by the net during the sets.

2.3. Objects

One of the objectives of this Pilot Action was to develop new designs for the artificial floating objects used in tuna purse-seine fishery. The main reason for this was that some materials used in manufacturing floating objects involve a potentially high risk of accidentally entangling different species, mainly sea turtles and sharks. The objects currently in use are bamboo racks, covered in netting—normally old nets used by the purse-seiner (Figure 1). Given that the risk of entanglement lies precisely with the netting, new materials for object manufacture were tested, where the tuna net was replaced by alternative elements that fulfil the same function of concentrating fish, but reduce or eliminate the likelihood of sea turtles becoming entangled. These materials included natural fabrics, jute and palm leaves. Experiments were carried out with a wide range of objects of different shapes and materials.

During the six months' data collection, various types of objects were tried, and the new ones were deposited alongside the traditional type in order to compare the results obtained.

Every time an object was visited, an observer checked the fauna entangled in it—mainly turtles and sharks.

Once in position, an object needs a certain amount of time to attract a tuna school. For this reason, prior to project commencement, the shipowners company deposited a series of experimental objects. Table 2 shows a list of the objects in position before project commencement, some of which were analysed during the project itself.

2.4 Buoys

The objects under which tuna are caught are natural—any element that happens to be found at sea—and artificial, deliberately positioned to concentrate tuna. Artificial objects are equipped with a buoy to facilitate location. There are currently several types of buoy, and those used for the project were: *SERPE*, *SATLINK*, *ZUNIBAL* and radio beacons.

2.5 Observers

Each vessel had a scientific observer on board for the duration of the Pilot Action. These observers were selected by the Spanish Oceanographic Institute from the qualified personnel available.

The scientific observers were trained beforehand by the IEO in taxonomy and methodology, and in specific software handling for entering observer data from the tuna purse-seiners. This facilitated entering scientific and basic fishery data about the commercial catch and accessory species of the fishery, as well as other necessary information specified in the forms used.

3. Results

Tables 3, 4 and 5 show the distance covered, the number of observation days and the number of grid squares visited, respectively, for each of the purse-seiners. Tables 6 and 7 contain the total distance covered and the observation days, per month, for both

support vessels. Figures 2, 3 and 4 give the various routes described by the four vessels. For the purse-seiners, each route corresponds to a trip, while for the support vessels, the two routes for each vessel correspond to a change of observer. Figure 5 shows the geographical location of the sets performed during the Pilot Action, distinguishing between positive and negative sets.

All the tables and figures help to situate the time-space strata studied during the project.

Figure 6 shows the number of objects, classified according to type. We observe that the artificial object marked with a buoy occupies first place with a considerable difference in comparison with the rest. In Figure 7, we can examine the destinations of the objects studied.

Table 8 presents the number of objects deposited, the number of visits undertaken, those fished and those collected without fishing, for each of the experimental object models. Table 9 provides a summary of the operations performed with all the objects used during the Pilot Action.

Table 10 shows the operations undertaken with the different types of experimental objects and gives the number of objects deposited, visited, collected without visiting, the number of sets and the catch made over each of them.

Table 11 contains the tuna, fauna and discard match for the total number of objects fished and for the experimental objects.

Table 12 gives the dead or live turtles found at the objects and in the surrounding area (not entangled) for all the objects analysed and for the experimental objects.

Figure 8 provides the geographical distribution of the objects found without buoys throughout the Pilot Action, while Figure 9 shows the objects marked with buoys.

Figure 10 shows the geographical distribution of all the objects deposited during the Pilot Action; figure 11, the visits made to the different objects; and Figure 12, the objects over which a set was performed. Figures 13, 14 and 15, give the total number of experimental objects deposited, visited and fished, respectively.

Figure 16 provides the geographical location of the sets involving turtle catches.

Figure 17 presents a sheet containing a description of several experimental objects tested throughout the project.

4. Discussion

The scientific report on the project presented the protocol that we considered most suitable for drawing conclusions with a scientific base and, therefore, certain credibility. The protocol specified that, throughout the six months' duration of the experiment, different types of objects would be tested by being deposited alongside the traditional type currently in use. The objects would be scattered in such a way that traditional and test objects were kept as close together as possible, since the area effect might be an important variable for the presence of certain species, particularly turtles. The same prototype would be tested at different times, with a view to equipping the analysis with a time component.

However, events prevented this plan from being carried out as anticipated, since practically no sets were performed over objects for the first three months (half the time available), as they lacked fish. Table 8 shows that a total of 22 different object models were tested—only 8 sets were performed over 5 of the 22 models. This makes it

impossible to draw final conclusions about the different models of objects used. However, we can establish a series of questions:

- Bearing in mind the number of visits made to experimental (111) and non experimental (690) objects, followed by the number of fisheries undertaken over them, if we maintain the same non experimental and experimental ratio, 30 sets would have been performed over experimental objects instead of the 8 that actually took place. This leads us to believe that, in principle, the tested objects are less likely to be successful for tuna fishery than traditional objects.

- However, assuming that both experimental and traditional objects were visited at random and considering the catch per set, the average catch for traditional objects was 44 tonnes, while for experimental objects it was 67 tonnes.

- Moreover, bearing in mind associated fauna, if we maintained the tuna/fauna catch ratio for non experimental and experimental objects, a total of 8.4 tonnes of associated fauna would have needed to be caught, instead of the 1.8 tonnes actually caught (Table 11). Consequently, we may conclude that experimental objects attract more tuna and fewer associated species.

- Finally, turning to turtle catches (Table 12), we observe that only one live—but no dead—specimen was found entangled in the experimental objects visited. The tuna netting that normally covered all experimental objects was replaced by another material, which immediately resulted in the absence of dead turtle specimens at these objects.

	Año construcción	TRB	HP	Eslora
Albacora Quince	1983	1507	4580	86
Albacán	1991	1516	4023	77
Taraska	1999	311	1400	36
Zahara Tres	2004	165	650	35

Table 1. Characteristics of the four vessels used in the Pilot Action

Nombre baliza		Tipo baliza	Tipo	Plantado por	Fecha Plantado
TRK	1	SL	C.M.0.6+7	TRK	29/04/2005
TRK	11	SL	C.M.4.2	TRK	24/03/2005
TRK	12	SL	P.S.1. 1+8	TRK	29/04/2005
TRK	13	SL	P.S.1. 1+8	TRK	13/05/2005
TRK	15	SL	C.M.4.6	TRK	24/04/2005
TRK	17	SL	C.M.0.6+7	TRK	29/04/2005
TRK	23	SL	P.S.1. 1+8	TRK	02/04/2005
TRK	28	SL	C.M.0.6+7	TRK	22/04/2005
TRK	33	SL	C.M.4.2	TRK	29/04/2005
TRK	34	SL	P.S.1. 1+8	TRK	19/03/2005
ABQ	40	ZB	C.M.4.3	ZH3	03/05/2005
ABQ	46	SL	C.M.0 6+0	ZH3	03/05/2005
TRK	47	SL	P.S.1. 1+8	TRK	24/04/2005
TRK	48	SL	C.M.4.6	TRK	29/04/2005
TRK	52	SL	C.M.4.6	TRK	19/03/2005
TRK	53	SL	P.S.1. 2+8	TRK	29/04/2005
TRK	57	SL	C.M.4.2	TRK	29/04/2005
TRK	66	SL	C.M.0.6+7	TRK	24/03/2005
TRK	84	SL	C.M.4.6	TRK	20/04/2005
ABQ	105	ZB	C.M.0 6+0	ZH3	25/04/2005
ABQ	139	ZB	C.M.0 6+0	ZH3	25/04/2005
ABQ	141	ZB	C.M.0 6+0	ZH3	25/04/2005

Table 2. List of objects deposited before the onset of the project

	mayo	junio	julio	agosto	septiembre	octubre	noviembre	Total
Cerquero 1	2980	4643	4846	5576	4137	4483	2644	**29309**
Cerquero 2	1021	4147	3116	4974	5278	4408	2415	**25359**

Table 3. Distance travelled (in nautical miles), per month, for both purse-seiners

	mayo	junio	julio	agosto	septiembre	octubre	noviembre	Total
Cerquero 1	21	30	31	31	26	25	22	186
Cerquero 2	7	24	22	26	29	22	15	145

Table 4. Observation days for both purse-seiners

	mayo	junio	julio	agosto	septiembre	octubre	noviembre
Cerquero 1	18	50	44	57	26	49	15
Cerquero 2	13	55	39	66	47	51	29

Table 5. Number of 1º x 1º grids visited by both purse-seiners

	Distancia recorrida
Auxiliar 1	26871
Auxiliar 2	28430

Table 6. Distance covered (in nautical miles) for both support vessels

	mayo	junio	julio	agosto	septiembre	octubre	noviembre	Total
Auxiliar 1	15	30	31	31	30	29	19	185
Auxiliar 2	16	30	24	32	30	31	16	179

Table 7. Observation days, per month, for both support vessels

Tipo de objeto	Modelo	Plantados	Nº Visitas	Recogidos sin pescar	Lances	Toneladas
Cilindros	CM023+8	1				
	CM06+0	8	14	6		
	CM06+7	4	6		1	20
	CM06+8	2				
	CM12	3	1			
	CM42	10	6	1	2	55
	CM43	14	9		3	330
	CM46	22	40	2	1	15
Parrillas	PS03+8	12	4	1		
	PS04	1	1			
	PS11		9	1		
	PS11+8	1	6	1		
	PS13	12	5			
	PS13+8	13				
	PS14	5	1			
	PS14+8		1			
	PS3	5				
	PS43	8	5	1		
	PS44	2	2			
	Restos cilind.			1		
Balsas	BS04	1				
	BM41+5	1	1		1	115
	E71+2	1				

Table 8. Model and number of experimental objects deposited, number of visits, fished and collected without fishing, in addition to the number of sets and tonnes obtained with them.

	Plantados	Nº visitas	Recogidos sin pescar	Lances	Toneladas
TOTAL	401	801	129	197	8620

Table 9. Total number of objects (experimental + non experimental) deposited, visited and collected without fishing, in addition to the number of sets and tonnes obtained with them

	Plantados	Nº visitas	Recogidos sin pescar	Lances	Toneladas
TOTAL	126	111	14	8	535

Table 10. Number of experimental objects deposited, number of visits and collections without fishing, in addition to number of sets and tonnes obtained with them

Total objetos			objetos experimentales		
atunes	**descartes**	**fauna**	**atunes**	**descartes**	**fauna**
8620.2	17.6	135.6	535.2	0	1.8

Table 11. Catch—in tonnes—of tuna, discards and associated fauna for all the objects and for the experimental objects

TOTAL	**Vivas**	**Muertas**	**No enmalladas**	**Total**
Caretta caretta	0	0	0	0
Chelonia mydas	0	0	10	10
Dermochelis coriacea	0	0	1	1
Eretmochelys imbricata	12	3	0	15
Lepidochelis kempii	1	0	0	1
Lepidochelis olivacea	0	5	3	8
Sin identificar	0	0	9	9
TOTAL	**13**	**8**	**23**	**44**
Objetos experimentales	**Vivas**	**Muertas**	**No enmalladas**	**Total**
Caretta caretta	0	0	0	0
Chelonia mydas	0	0	0	0
Dermochelis coriacea	0	0	0	0
Eretmochelys imbricata	1	0	2	3
Lepidochelis kempii	0	0	0	0
Lepidochelis olivacea	0	0	1	1
Sin identificar	0	0	0	0
TOTAL	**1**	**0**	**3**	**4**

Table 12. Number of turtles found, alive, dead or near the object (not entangled) and the total number during the Pilot Action (one specimen was caught and classified by an observer as *Lepidochelis kempii*; however, this species is not cited for the Indian Ocean. Furthermore, it has several characteristics that are unclear and might lead to an incorrect classification. As a result, this mention is made with reservations).

Figure 1**.** Traditional objects.

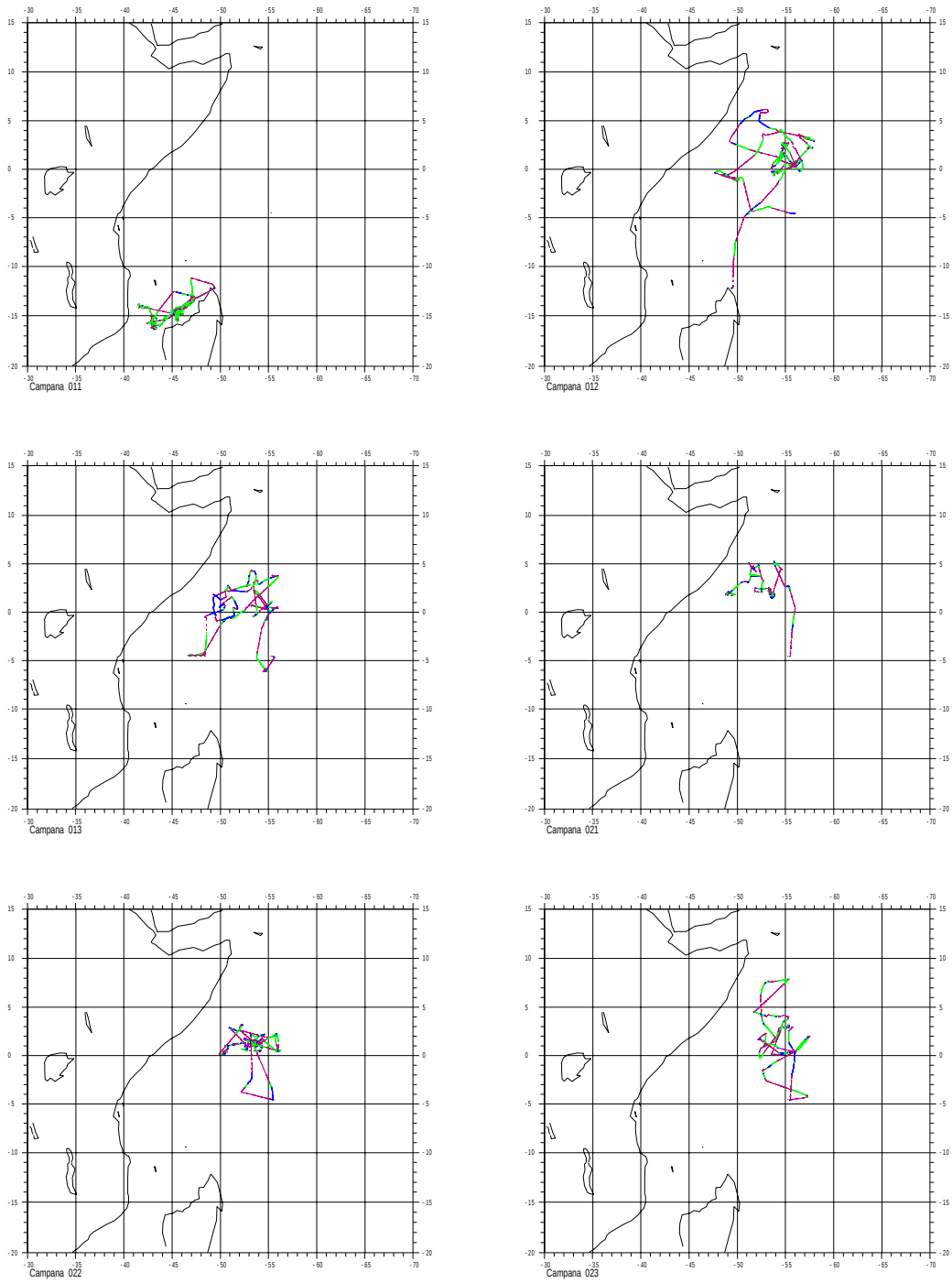


Figure 2. Route of purse-seiner 1 for first six trips

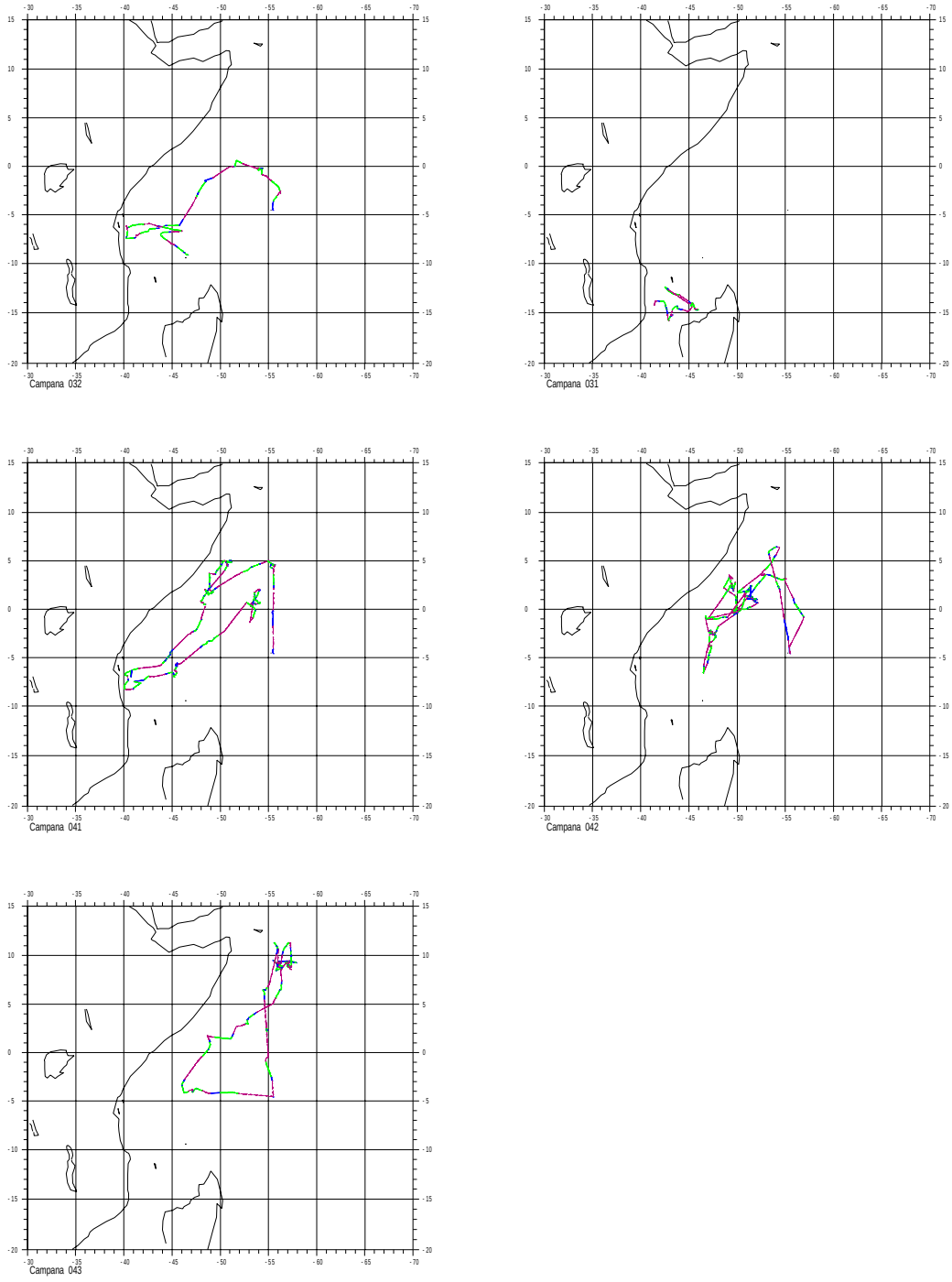


Figure 3. Routes of trips made by purse-seiner 2

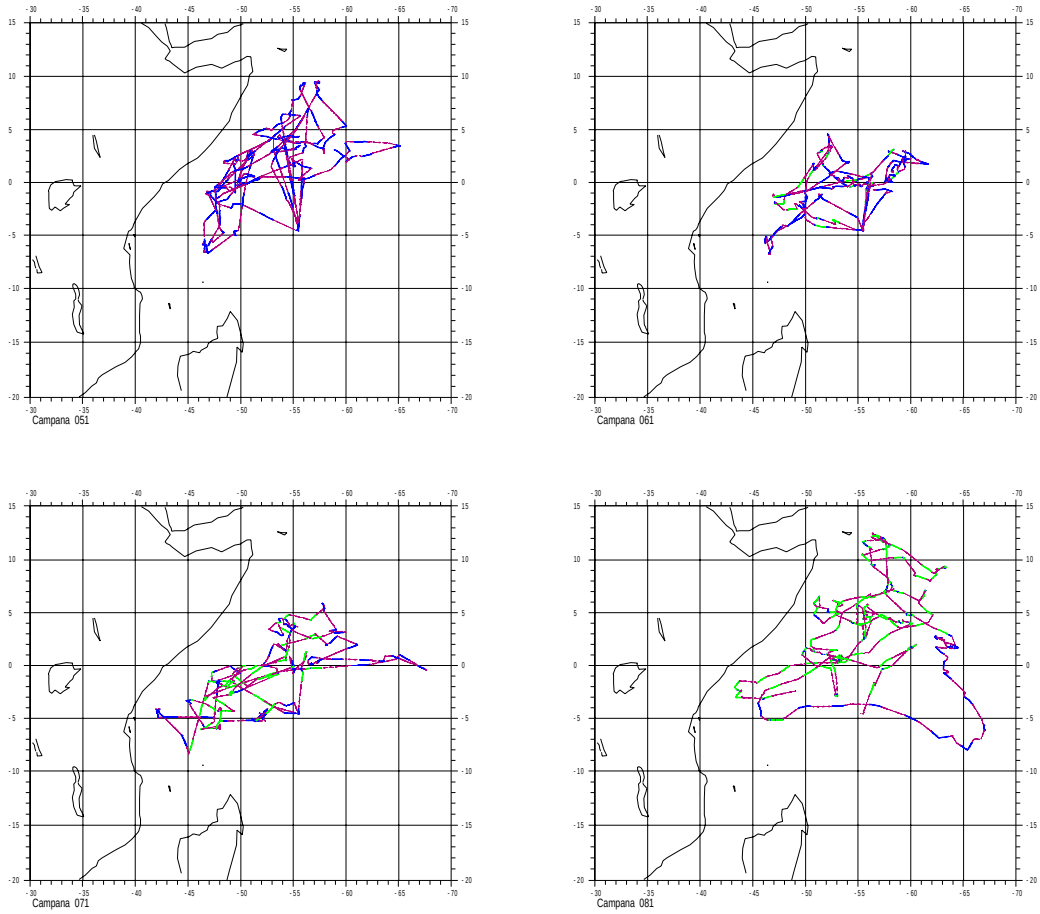


Figure 4. Routes of both support vessels

.

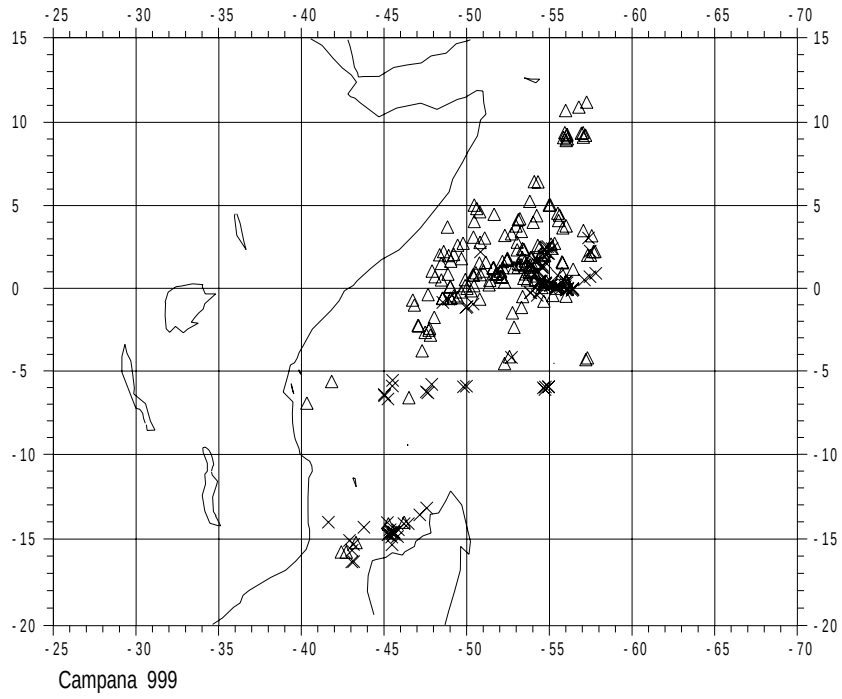


Figure 5. Sets performed throughout the Pilot Action (Δ = positive; X= null)

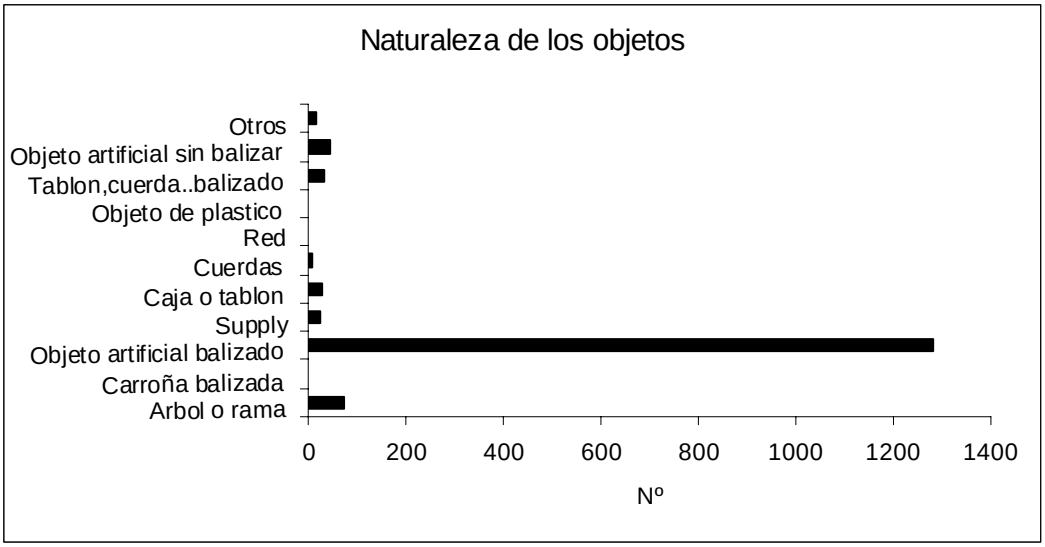


Figure 6. Number of objects classified according to their nature

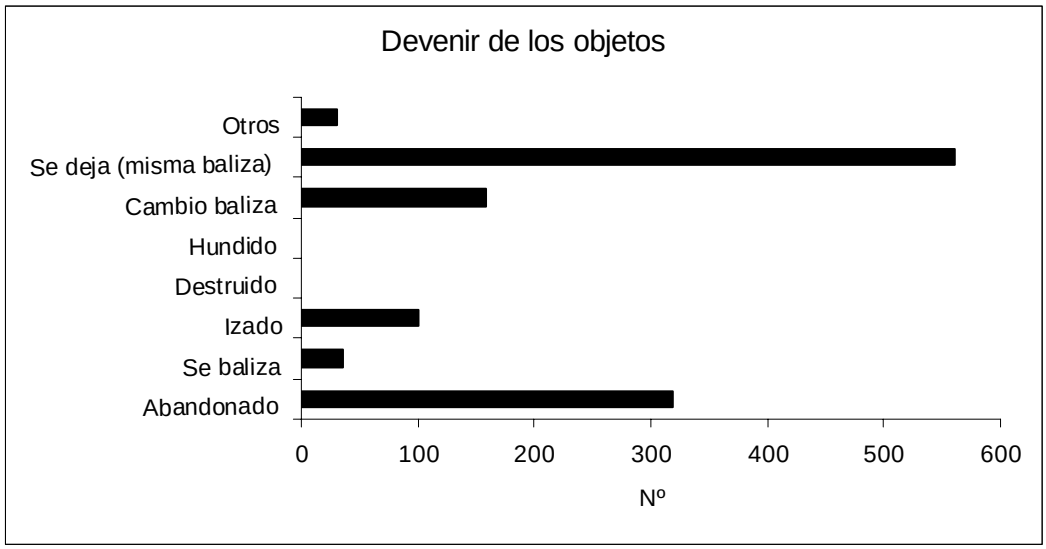


Figure 7. Different destinations of the objects

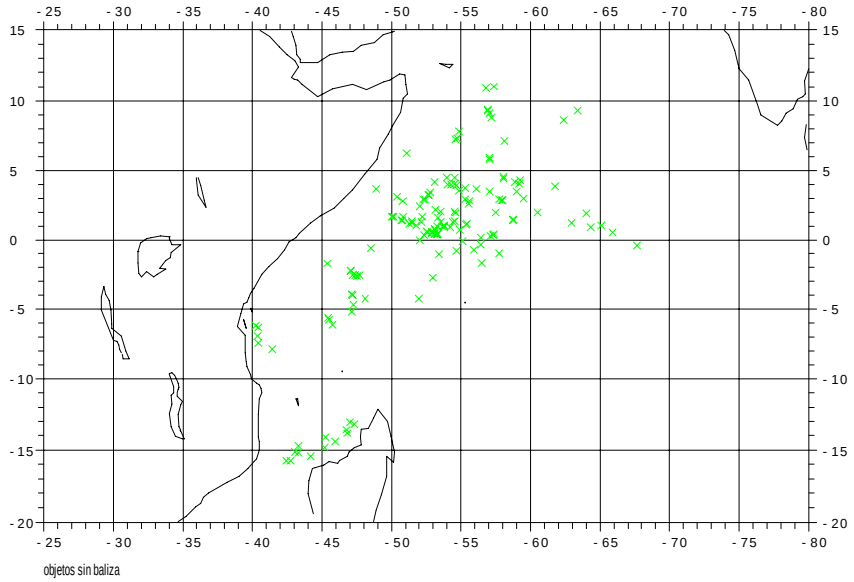


Figure 8**.** Total number of objects found without buoys

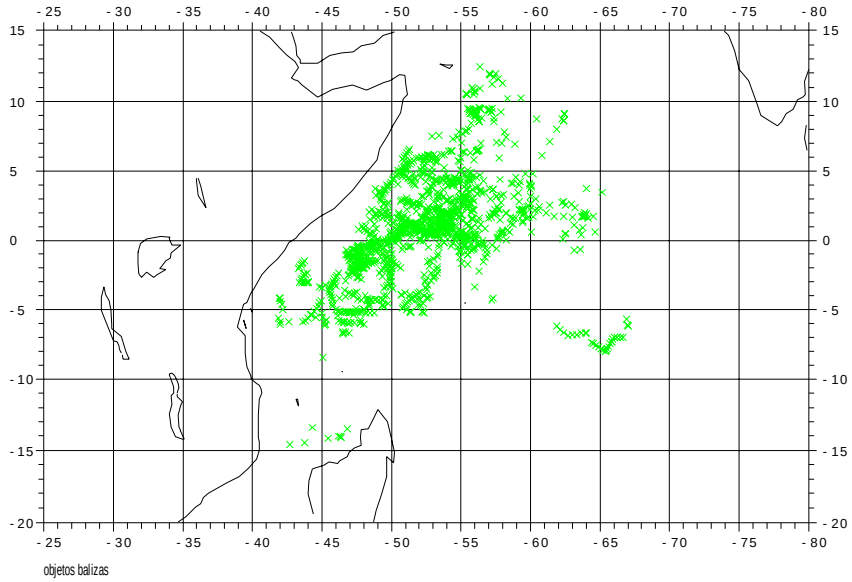


Figure 9**.** Total number of objects with buoys

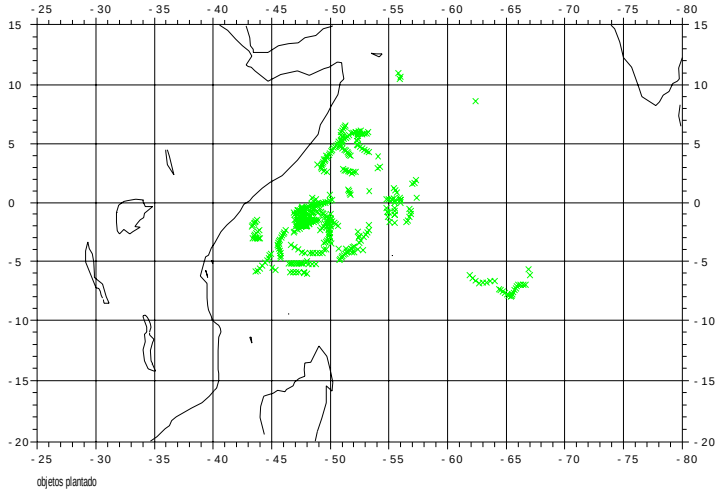


Figure 10**.** Total number of objects deposited throughout the Pilot Action

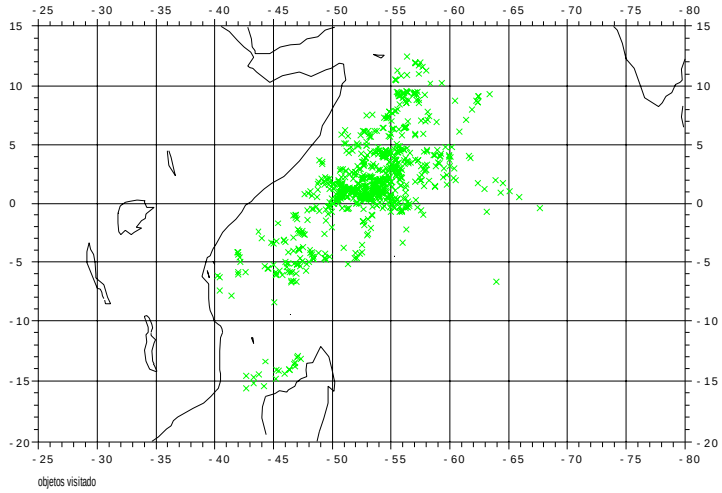


Figure 11**.** Visits made throughout the Pilot Action

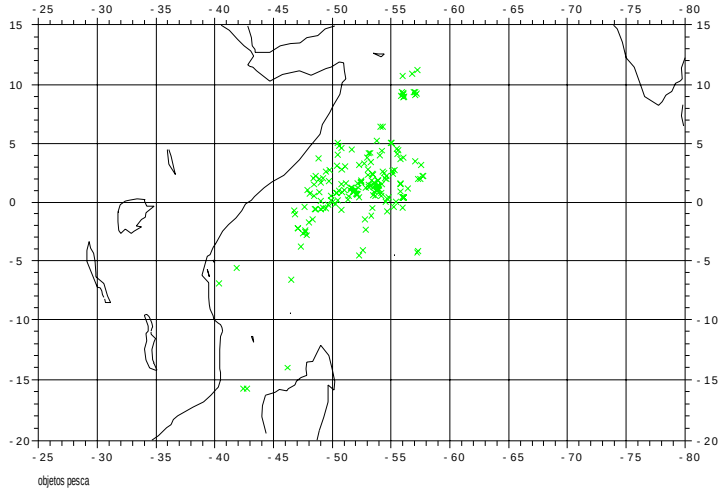


Figure 12**.** Total number of objects fished throughout the Pilot Action

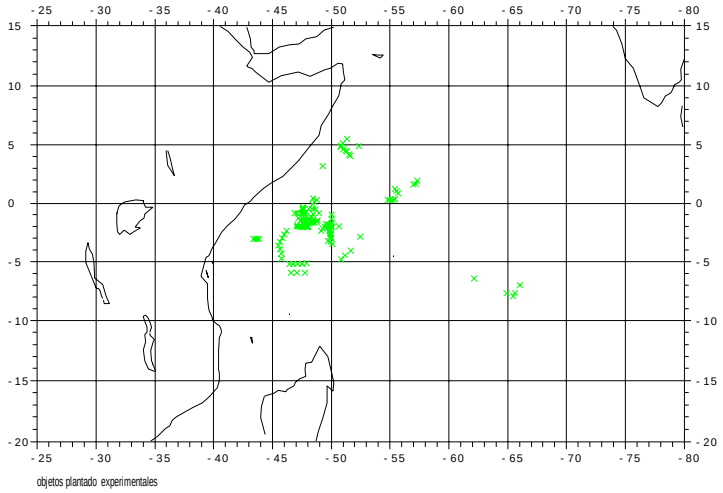


Figura 13.-Total de objetos experimentales plantados a lo largo de la Acción Piloto

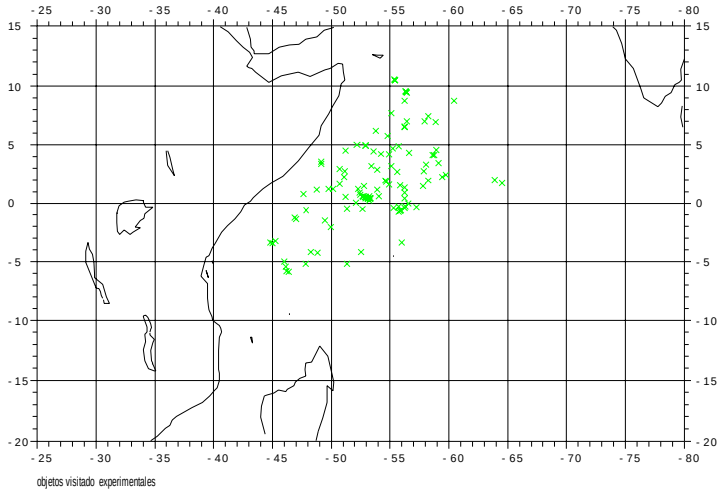


Figure 14. Visits to experimental objects throughout the Pilot Action

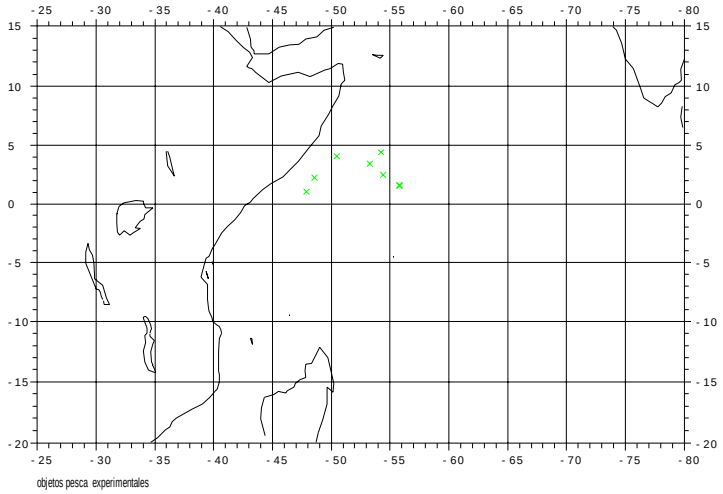


Figure 15. Total number of experimental objects fished throughout the Pilot Action

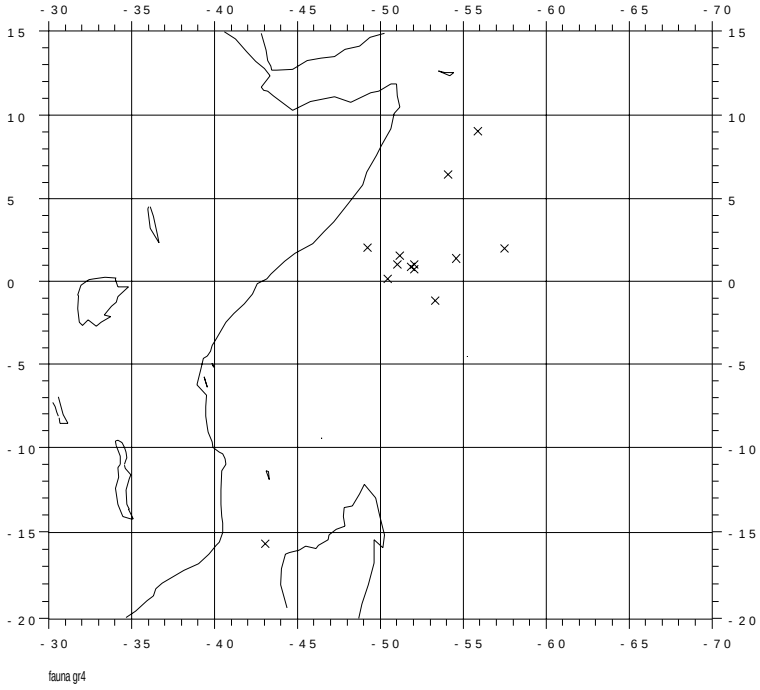


Figure 16**.** Geographical location of sets with turtles

EXPERIMENTAL OBJECT CM46

Size: cylinder of 3m – 6m length by Ø 1.5 m - 2 m.

Material: rubber tubing, sailcloth, and ropes.

Colour: green

Description: cylinder with frame composed of a different number of hoops (according to size); the top and bottom hoops are rubber tubing (Ø 50 mm) filled with sand for ballast, while the central hoops are empty rubber tubing (Ø 25 mm). The covering is green sailcloth, fixed to the hoops by several ropes. It has no extension.

These are underwater and not surface objects.

Figure 17. Cards of experimental objects used in the Pilot Action

OBJETO EXPERIMENTAL CM12

Size: cylinder of 3 m – 6m length by Ø 1.5 - 2 m.

Material: rubber tubing, jute and ropes.

Colour: light brown

Description: cylinder with frame composed of a different number of hoops (according to size); the top and bottom hoops are rubber tubing (Ø 50 mm) filled with sand for ballast, while the central hoops are empty rubber tubing (Ø 25 mm). The covering is made of jute and tied to the hoops by several ropes. Two extensions in the shape of a jute curtain, which vary in length from 3 to 8 metres, hang from the bottom rubber tubing.

These are underwater and not surface objects.

Figure 17. (Continuation)

OBJETO EXPERIMENTAL CM06+0

Size: cylinder of 3m – 6m length by Ø 1.5 m - 2 m.

Material: rubber tubing, sailcloth, tuna boat netting and ropes.

Colour: green (the cylinder) and black (the tail).

Description: cylinder with frame composed of a different number of hoops (according to size); the top and bottom hoops are rubber tubing (Ø 50 mm), filled with sand for ballast, while the central hoops are empty rubber tubing (Ø 25 mm). The covering is made of green sailcloth, tied to the hoops by several ropes. It carries 15 m long tuna boat netting, tied to the bottom hoop of the cylinder with four guys. Half canes are inserted with sections of chain at every 5 m along the tail to serve as ballast and to ensure that the object remains underwater.

These are underwater and not surface objects.

Figure 17. (Continuation)

OBJETO EXPERIMENTAL CM023+8

Size: cylinder of 2.20 m length by Ø 1.10 m and ropes 4 m in length.

Material: rubber tubing, semi-natural fabric, jute, ropes and sisal ropes

Colour: light brown (jute), blue and green (natural fabrics).

Description: cylinder whose frame is composed of three rubber tubes (Ø 50 mm) arranged in a circle, without filling. The covering is composed of four pieces of cloth (each 1 m in length): two made of jute, one in blue fabric and another in green fabric, placed opposite each other and tied to the tubing by ropes. Two rope ends of around 4 m in length and Ø 35 mm hang from the bottom tube.

These are underwater and not surface objects.

Figure 17**.** (Continuation)

OBJETO EXPERIMENTAL PS13+8

Size: grids of 2.50 m. × 1.80 m.

Material: bamboo canes, semi-natural fabrics, rope and corks.

Colour: brown bamboo canes, and green and blue fabrics.

Description: frame composed of a bamboo cane grid with four buoys, one at each corner. The covering is made of semi-natural fabrics, in blue and green, which are tied to the canes by ropes. These fabrics fall like a curtain on both sides of the grid, and sections of chain have been attached on each side to give more weight and to ensure that the curtain falls deep. On the bottom, two or three ropes (Ø 35 mm) between 7 and 12 m long hang from the central area.

These are surface objects.

Figure 17. (Continuation)

OBJETO EXPERIMENTAL PS14+8

Size: grid of 1.5m × 2 m. Bunch of palm leaves around 3.5 m long.

Material: bamboo canes, palm leaves, corks and nails.

Colour: brown.

Description: frame composed of a bamboo cane grid of approx. 1.5 m × 2 m, covered in palm leaves that have been nailed in place and have an overhang of up to 3 m. In addition, two bunches of palm leaves overhang both sides of the pallet to a good depth. 4 corks help maintain floatability. A 1.20 m rope end hangs from the bottom centre of the pallet.

These are surface objects.

Figure 17**.** (Continuation)

OJETO EXPERIMENTAL PS13

Size: grid of approx. 1.70 m. × 1.70 m.

Material: bamboo canes, ropes, semi-natural fabric and buoys.

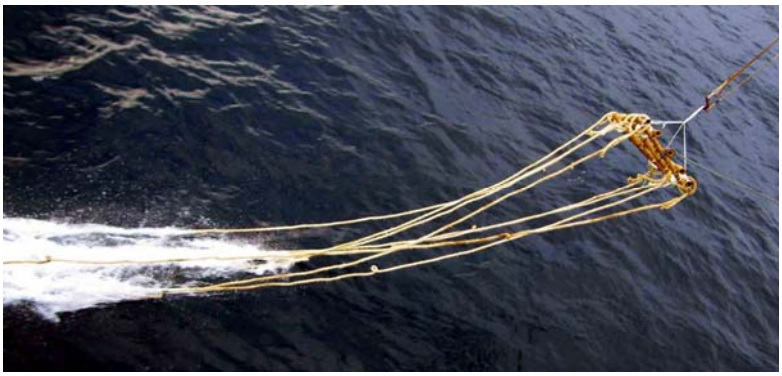
Colour: brown canes and blue and green fabric.

Description: frame composed of a bamboo cane grid with four buoys, one at each corner. The covering is made of semi-natural fabrics that may be of one or two colours, which are tied to the canes by ropes. These fabrics fall like a curtain on both sides of the grid, and sections of chain have been attached on each side to give more weight and to ensure that the curtain falls deep.

These are surface objects.

Figure 17. (Continuation)

OBJETO EXPERIMENTAL PS3



Size: grid of 2.70 m. × 1.70 m.

Sisal ropes of between 7m – 12m.

Material: bamboo canes, ropes, sisal ropes and corks.

Colour: brown.

Description: grid made up of bamboo canes and 4 corks. Four sisal ropes hang from each of the two longer lateral bamboo canes.

These are surface objects.

Figure 17**.** (Continuation)