

Hooks equipped with magnets can increase catches of blue shark (Prionace glauca) by longline fishery

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1	Hooks equipped with magnets increase catch of blue shark (Prionace glauca) by
2	longline fishery
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13	
14	Short title. Magnets do not reduce by-catch of blue shark

16 Abstract

15

17 The blue shark (Prionace glauca) populations are decreasing wordwide and the species 18 is currently classified as near threatened. However it is the main species caught by the Spanish and Portuguese longline fisheries; and blue shark is specifically targeted by a 19 part of these fleets in the northeastern Atlantic Ocean. Sharks are well known to be able 20 to detect electric fields in the microvolt range and this sense has been proposed to 21 provide a mechanism to detect the earth's magnetic field. As a result, the use of magnets 22 23 has been proposed as a measure to reduce shark interaction with fishing gear. We therefore tested two models of high field strength neodymium magnets to effect shark 24 25 catch rates during commercial longline fishing operations. Our results show that magnets 26 do not reduce blue shark catch rates and can even have an attractive effect. This effect 27 was significantly higher for the larger magnet model tested (26 mm x 11 mm x 12 mm, 0,885 T) compared to the smaller one (20 mm x 13 mm x 15 mm, 0,464 T). We also 28 29 noted that hooks remain magnetized after removal of the magnets and are even slightly magnetized without any previous contact with a magnet. 30

31

33 Keywords

34 Blue shark, by-catch, longline, magnet, repellent, CPUE

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36 **1. Introduction**

37

The blue shark *Prionace glauca* (Linnaeus, 1758) is a species with worldwide
distribution (Moreno, 2004). Like most of pelagic shark species, the blue shark presents
a low fecondity rate and a slow growth rate (Ferretti et al., 2008) and is therefore

41 particularly vulnerable to fishery exploitation.

42 In the northeastern Atlantic Ocean, one part of the Spanish and Portuguese longline

43 fleet targets swordfish *Xiphias gladius* Linnaeus, 1758, tuna (teleosts of the group

44 Thunini) and shortfin mako near Azores archipelago and between Azores archipelago

45 and Iberian Peninsula (Buencuerpo et al., 1998; Stevens et al., 2000; Baum and Myers,

46 2004). The bait is mackerel (*Scomber scombrus*). However, about 60% of the catch is

47 represented by blue shark (Xunta de Galica. pers. comm.). The second part of the

48 longline fleet concerned by this study targets only blue shark (*Prionace glauca*) near

49 Iberian Peninsula. The bait is longfin inshore squid (*Doryteuthis pealeii*). Over 200 tons

50 of blue shark were landed each month in 2013 in Vigo (Xunta da Galicia, i.e. regional

51 government, pers. comm.). In both case, Spanish and Portuguese longline fishermen can

52 be interested by a repulsive system as if they catch more commercial species like

swordfish and tuna they may increase their profit. Moreover most pelagic sharks are on
top of the food web and play an important role in marine ecosystems as they contribute
to the management of healthy ocean ecosystems (Ferretti et al., 2010).

56 Elasmobranchs use the electric sense due to the ampullae of Lorenzini for the detection

of the bioelectric fields produced by prey organisms (Kalmijn, 1971). However the

58 chemoreception will be probably used on large distances to detect prey even if at a

59 small distance from the prey electric sense may influence their behaviour. According to

60 Hueter et al. (2004) *Prionace glauca* is attracted to an area by odor but preferentially

61 attacked an active dipole source that simulated the prey's bioelectric field rather than

62 the odor source of the prey. This electric sense is also related to their two modes of

63 navigation. In the passive mode, the elasmobranch simply measures the electric fields

are produced by the flow of ocean water through the Earth's magnetic field. In the

active mode, the elasmobranch measures the voltage gradients that are induced through

the animal's body due to its own swimming movements through the geomagnetic field(Hueter et al., 2004).

Permanent magnets have been shown to have repellent effect on sharks by creating anabnormally strong electrical stimulus to overwhelm the elasmobranchs' acute

ro electrosensory system (Stoner et al., 2008; Tallack and Mandelman, 2009; O'Connell et

al., 2011a, 2012; Hutchison et al., 2012). Magnets constitute therefore a possible means

to reduce the by-catch. Actually, among 20 pelagic shark species concerned by fisheries

and/or bycatch, three are now classified by the International Union for the Conservation

of Nature (IUCN, 2013) as endangered, namely *Mobula mobular* (Bonnaterre, 1788),

75 Sphyrna lewini Griffith & Smith, 1834, Sphyrna mokarran Rüppell, 1837, nine as

vulnerable, namely *Alopias pelagicus* Nakamura, 1935, *A. superciliosus* Lowe, 1841, *A.*

vulpinus (Bonnaterre, 1788), Carcharodon carcharias (Linnaeus, 1758), Cetorhinus

78 maximus (Gunnerus, 1765), Isurus oxyrinchus Rafinesque, 1810, I. paucus Guitart,

79 1966, *Lamna nasus* (Bonnaterre, 1788), *Sphyrna zygaena* (Linnaeus, 1758), and one, *P*.

80 *glauca*, as near threatened.

71

During the last years, many works tried to test the deterrent electromagnetic effect on sharks (Annexe 1). They used permanent magnet composed by Barium (Ba), Boron (B), Iron (Fe) and Neodymium (Nd) or electropositive metal (EPM) composed by Lanthanides metal. Different EPM tested were Barium (Ba), Neodymium (Nd), Praseodymium (Pr), Cerium (Ce), Cerium-Lanthanum (CeLa), Praseodymium-Neodymium metal alloy (PrNdA), and Praseodymium-Neodymium mischmetal (PrNdM) (Annexe 1).

88 The tests published were realized in laboratory (in experimental conditions) or in field

89 (in experimental conditions, in experimental fishing or in real fishing conditions). Many

90 species were used to test several magnet models or EPM. Some species have a pelagic

91 behaviour (Dasyatidae, Carcharhinidae, Lamnidae, Sphyrnidae and Triakidae) and

92 others, a benthic behaviour (Rajidae and Squalidae). The results show contrasted

93 effects. In laboratory, the results of experiments are sometimes positive (Brill et al.,

94 2009; Rigg et al., 2009; O'Connell et al., 2010; Jordan et al., 2011; O'Connell et al.,

2011b, 2014a, 2014c; Smith and O'Connell, 2014), and sometime, negative or partial

96 (Stoner and Kaimmer, 2008; Rigg et al., 2009; Jordan et al., 2011; McCutcheon and

97 Kajiura, 2013). Tests realized in field obtained both positive (Rice, 2008; Wang et al.,

98 2008; O'Connell et al., 2011a, 2014b, 2014d, 2015) and negative results (Robbins et al.,

- 99 2008; Tallack and Mandelman, 2009; O'Connell et al., 2011a; Hutchinson et al., 2012;
- 100 Godin Cosandey et al., 2013; Smith, 2013; O'Connell et al., 2014d).
- 101 Some species may have opposite behaviour in different conditions. For example,
- 102 smooth dogfish (Mustelus canis) in contact with Neodymium (Nd) metal can have a
- 103 repellent reaction in group but not alone (Jordan et al., 2011). *Carcharhinus plumbeus*
- 104 can have a repellent reaction in laboratory (Brill et al., 2009) but not in field (O'Connell
- et al., 2011a). Globally, all the tests with electromagnetic dispositive obtained highly
- 106 contrasted results between laboratory and field experiments, between species and107 according to the electromagnetic dispositive.
- 108 Repellent effects with EPM were proposed to be used to limit the intense fishing
- 109 activities especially for blue shark (*Prionace glauca*) and shortfin mako (*Isurus*
- 110 *oxyrinchus*). However, previous experiments realized in field and in real fishing
- 111 conditions with EPM, were negative for both species (Hutchinson et al., 2012; Godin
- 112 Cosandey et al., 2013).
- 113 The aim of this paper was to test the effects of neodymium magnets on catches of the
- blue shark aboard a fishing vessel targeting pelagic species in the eastern Atlantic
- 115 Ocean. This is the first paper measuring and taking into account the physical properties
- 116 of the magnets and their effect on the hooks.
- 117

118 **2. Methods**

- 119
- 120 *Physical properties of the two magnet models*
- 121 The magnet is mainly composed of neodymium, a magnet element with high resistance
- in time and magnet power. The magnets were of the N35-Ni and N35-NdFeB types.
- 123 The higher the grade (the number following the 'N'), the stronger the magnet. Ni
- 124 indicates the presence of traces of nickel. NdFeB indicates that the magnet is composed
- 125 of neodymium, iron and boron. Neodymium is a rare-earth magnet element with
- degradation trends in sea water. However the experiment lasted only 3 days and there
- 127 was no degradation of the magnets. We did not measure the level of dissolution in
- 128 laboratory because as the lanthanides dissolve, the voltage (mV) remains unchanged
- despite the decreasing mass (McKutcheaon and Kajiura, 2013).
- 130 The dimensions of the two cylindrical magnet models with a central hole, tested were
- 131 26 mm x 11 mm x 12 mm (model 1, 0,885 tesla from Ingeniera Magnética Aplicada,

132 Barcelona, Spain) and 20 mm x 13 mm x 15 mm (model 2, 0,464 tesla - from Firstmagnetic, Roncq, France). The magnetic fields produced by the two types of 133 134 magnets, with the hook, were measured at several distances (between 7 and 70 cm). We also measured the magnetic fields of two hooks after contact with the two types of 135 136 magnets and the magnetic fields of a hook which was never in contact with magnets. 137 As each model has always been composed of three magnets in experiments, we report 138 here the measurements for sets of three magnets. When magnets are stuck together, the magnetic field produced by three magnets is not exactly equal to three times the field 139 140 produced by one as they are not physically at the same point (the more distant magnet has a lower influence, due to the increasing discrepancy of magnetic field with 141 142 distance). But at a long distance in relation to the size of the magnet, the field can be considered as approximately three times the field of each. 143 The hook used in the experiments is made of steel, a ferromagnetic material. In 144 145 consequence, it concentrates the magnetic lines and changes the map of the magnetic field. Moreover, the size of the hook is much larger than the size of the magnets so that 146 very close to the hook, if the magnets are on the opposite side of the hook, the magnetic 147 148 field can be greater than what it would be with the magnets alone. To measure precisely 149 the field produced, we used a Gauss/Teslamètre Sypris 7030 F.W.Bell and recorded the variation in the magnetic field in a figure that gives the magnetic field in tesla units 150 along the distance X in centimeters for a hook filled with respectively big magnet (big 151 152 circle) and small magnet (small circle) in a log-log scale. The measurements were made 153 from the position of the center of the magnet on the hook (approximate position when magnet was absent). The magnetic fields of two hooks after contact with the two types 154 155 of magnets and the magnetic fields of a hook which was never in contact with magnets were also recorded in the same figure. 156

157

158 Experiments under real fishing conditions

159 The experiments were carried out in the northeastern Atlantic Ocean $(8^{\circ} - 9^{\circ} W \text{ and } 42^{\circ}$

160 -45° N) (Figure 1) aboard a longline fishing vessel, during 3 days (October 2013). The

161 vessel, the *Pescalema*, was based in Muxía, a small port in Galicia (Spain). The vessel,

- ~ 20 m long, carried 8 crew members, plus the scientific observer (SBP). The
- 163 experiments concerned 1076 shark individuals. We determined their sex and

approximate size. They belonged to the following size classes (cm): [90-100), [100-

165 110), [110-120), [120-130), [130-140), [140-150), [150-200), [>200.

166 The longline measured about 50 km with 1 300 hooks, about 40 m apart. Hooks were

located at about 20 m depth. The ring-shaped hooks (model 9202, Mustad[™], Lilleaker,

168 Oslo area, Norway) measured 8 cm in total height and 2 cm in width.

169 The shape and size of the magnets were chosen to correspond to the size of the hook170 (Figure 2).

A positive and encouraging aspect of the experiment was that the fishermen were able 171 172 themselves to place the magnets on the hooks without the assistance of the scientist (SBP), who just passed them the magnets stored in a polystyrene box. Inserting the 173 174 hook within the magnet did not reduce the hectic speed of the immersion of the baited 175 hook and the supporting line, lasting 7-8 h, by night, during a real fishing operation. 176 The polarization of the magnets was randomly orientated so that the magnetic field N or 177 S corresponded to the hook axis. Fishermen had no difficulty in attaching the magnets and removing them from the hook. The bait was located close to the magnet so that 178 179 sharks would feel the magnetic field when trying to feed. The fishermen used only longfin inshore squid (Doryteuthis pealeii) (Lesueur, 1821) as bait. The longline carried 180 the same number of hooks during the three days of the experiment. We divided the 181 longline into 3 test zones with the same number of hooks (zone 1 at the beginning of the 182 longline, zone 2 in the middle of the line and zone 3 at the end) and the rest of the 183 184 longline was the zone 4 (Table 1; Figure 3). The reason for this partitioning is that zone 185 1 remained immersed for a longer time than zone 3 (approximately 7 hours) and this may influence the catch values. Within each test zone, we used 5 hooks with magnets of 186 187 the first model, 11 hooks with magnets of the second model and 16 control hooks without magnets (Figure 3). The aim of this strategy was to observe whether there was 188 189 any significant difference in the catch rate between test hooks and control hooks and 190 between the two types of magnet within test zones. The rate of catch per unit of effort 191 (CPUE) represents the relation between the number of individuals in catches and the 192 number of hooks.

193 The three days were considered as replicates. We compared catch values for the 144 194 hooks with magnets from test zones 1 to 3 with144 control hooks under normal fishing 195 conditions (i.e. without magnets)(Table 1). Inside the test zones, we tested the influence of different factors (size, sex, presence or absence of magnets and the models ofmagnet) on the CPUE values.

198

199 *Data treatment*

Data were analyzed with Statistica 9.1. Normality and homogeneity of variance were previously tested using Shapiro and Levene tests. One-way ANOVA was used in each zone and for all the tested zones together to test the differences in CPUE values between hooks with magnets and control hooks as well as between the two models of magnet.

204

205 **3. Results and discussion**

206

207 *Physical tests*

208 Figure 4 shows the measurement of the magnetic field in tesla (T) along the distance X

in cm for a hook carrying respectively big magnets (big black circles) and small

210 magnets (small grey circles) in a log-log scale. The lines correspond to the theoretical

variation of the magnetic field as X^{-3} . We note that despite the presence of the hook, for

a distance more than 10 cm, the magnetic field intensity varies like that of a dipole. At

these distances, the intensity of the large magnets was twice as high as that of the

smaller magnets.

215 The intensity of the magnetic field produced by the magnets has to be

compared with the additional intensity of the magnetic field of the Earth (between

217 0.00002 T and 0.00007 T, depending on the position on the Earth). From figure 4, we

218 note that the intensity of the magnetic field from the magnets was the same

219 intensity as that of the magnetic field of the Earth at a distance around 25 to 35 cm for

small magnets, and 30 to 45 cm for big magnets.

An important aspect to be considered is that hooks equipped with both big and small

222 magnets remained magnetized when removing the magnets and this phenomena is

permanent (Figure 4). For example, a hook magnetized after contact with a big magnet

at 6 cm distance induced the same magnetic field that a hook with a big magnet at 7 cm

distance. Moreover, a hook alone which was never in contact with a magnet shows also

a measurable magnetic field, even if it's lower than the magnetic field of hooks after

227 contact with a magnet. For example at 6 cm distance from the hook which was never in

- contact with a magnet the magnetic field is equivalent to that of a hook with a bigmagnet model 1 measured at 8 cm distance.
- 230

231 *Experiments under real fishing conditions*

232 During the fishing campaign, 1 076 blue shark *Prionace glauca* were caught by the

longline vessel (Figure 5; Table 2). In addition to the blue sharks, one small swordfish

234 Xiphias gladius, one albacore Thunnus alalunga (Bonnaterre, 1788), 3 sunfish Mola

mola (Linnaeus, 1758), 6 pelagic stingray *Pteroplatytrygon violacea* (Bonaparte, 1832)

and one common thresher shark *Alopias vulpinus* were caught.

237 The total length of the captured blue sharks ranged from 70 to 240 cm, corresponding

mainly to juvenile individuals (Table 2). For the blue shark, sexual maturity is reached
at 180 cm in males and 200 cm in females (Moreno, 2004).

240 Sex ratio (% of males) was 0.52 - 0.55 in the tested zones 1 to 3 and 0.77 in the zone 4.

241 The total length and sex of the caught individuals did not differ significantly according

- to whether they were caught with hooks equipped with magnets or not (p=0.062,
- respectively p=0.892).
- 244 The presence of the magnets had a significant effect on the catch rate per unit of effort
- 245 (CPUE) only in the zones 2 (F=10.48; p=0.014) and 3 (F=7.99; p=0.026) with higher
- 246 CPUE values for hooks equipped with magnets in both areas (0.73 in zone 2 and 0.75 in
- zone 3 for hooks with magnets compared to 0.52 and 0.38 respectively for hooks

248 without magnets) (Table 1; Figure 6). These values were significantly higher only for

the hooks equipped with the model 1 magnet (0.80) than for the control hooks in the

zone 2 (0.52) (F=5.25; p=0.048). In contrast, there were no significant differences in

251 CPUE between the two magnet models 1 and 2, between model 2 magnet hooks and the

control hooks in the zone 2, and between the two magnet models and the control hooks

- in the zones 1 and 3.
- 254 Globally for all the tested areas CPUE values for hooks with magnets are higher than
- those of hooks without magnets (mean 0.74, SD 0.15 and respectively mean 0.47, SD
- 256 0.17) (F=18.29, p=0.000). These values are also higher than those of CPUE in the zone
- 4 (mean 0.25, SD 0.43). However as the number of hooks is much higher in the zone 4
- 258 (1204 hooks x 3 days) than in the tested zones (48 hooks x 3 days) this might influence
- the comparison between the mean CPUE values among these zones.

260 It remains unclear whether it is the absolute strength of the magnetic field in the water, which at some level induces reaction behaviour of blue sharks, or whether it is the 261 262 magnitude of the change in magnetism with distance that elicits the response. However, the presence of magnets near the hook did not provide the expected repellent effect. One 263 264 of the two tested models of magnet even increased the catch rate. Magnets would 265 therefore not appear to constitute an effective device to avoid by-catch for this species 266 in real fishing conditions. Our results would appear to contradict these promising experimental previous results. However, several factors are to be considered. (i) Results 267 268 from the literature are mainly based upon laboratory experiments, and/or in situ experiments more or less remote from the real conditions of a professional fishing fleet 269 270 (Stoner and Kaimmer, 2008; Tallack and Mandelman, 2009; O'Connell et al., 2011a, 2014; Robbins et al., 2011). (ii) Clearly, the results from previous authors evidence the 271 272 non-congruence of deterrent effects depending upon the species (Hutchinson et al., 273 2012); for example, these authors showed the ineffectiveness of EPM with blue shark and shortfin mako, although effective with another species (Annex 1). (iii) Our results, 274 together with similar results from the literature (e.g. Hutchinson et al., 2012), concern 275 276 juveniles. It is known that the electrosensory sensitivity, in many elasmobranchs, increases with growth (e.g. Fishelson and Baranes, 1999; Tricas and Sisneros, 2004). 277 (iv) The repellent devices used in the literature are rather disparate. Their characteristics 278 279 and strength are often poorly described. In addition, the effectiveness of the magnet is 280 influenced by the parallelism, or non-parallelism, of the axis of polarization with the 281 axis of the hook (O'Connell et al., 2011a). Most of the previously published papers on the deterrent effect on sharks tested the 282 283 effects of electropositive metals (Annex 1), excepting Rigg et al., (2009). This is the first paper describing the magnetic effect on blue shark catch. Previous papers 284 285 concerning the blue shark analyzed only the electropositive effects (Godin Cosandey et al., 2013; O'Connell et al., 2014d) (Annex 1). In our case, blue shark probably detects 286 287 by odour at a large distance the presence of bait on the longlines. However at a short

- 288 distance when swimming towards the bait it should feel the electric field induced by
- both the magnet and the electropositive metal. We probably have a cumulated effect of
- electric field induced the shark movement in the magnetic field and an electric field
- 291 generated by the electropositive metal in contact with seawater that we cannot dissociate

292 in field conditions. The measurements in laboratory concerned only magnetic field, but in perspective we will try to develop a protocol to measure the electric field too. 293 294 Our results, as well as others experiments in real fishing conditions did not reduce the 295 by-catch of sharks (Godin Cosandey et al., 2013). Permanent magnet or electropositive 296 metal is actually not proved yet as a solution to limit by-catch or to reduce negative 297 impact of longline fisheries. As suggested by Jordan et al., (2013), we will have to 298 explore new approaches to reduce the by-catch of sharks, as magnets seem to even have an attraction effect. Other management measures such as quotas or minimum catch 299 300 length may be more appropriate for blue shark fishery.

301

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303

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310

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Tables

Table 1. Comparison of mean values of CPUE (catch per unit of effort, where the unit of effort was the number of hooks) for blue shark (*Prionace glauca*) between longline zones during the test period (3

days). No=number. SD=Standard Deviation.

Blue shark catch tests	Zone 1		Zone 2			Zone 3			
	No of	CPUE	SD	No of	CPUE	SD	No of	CPUE	SD
	hooks			hooks			hooks		
Magnet model nº1	3x5	0.87	0.35	3*5	0.80	0.45	3*5	0.80	0.41
Magnet model nº2	3x11	0.64	0.49	3*11	0.70	0.47	3*11	0.70	0.47
Hooks without magnets	3x16	0.52	0.51	3x16	0.52	0.50	3x16	0.38	0.49

421 422 Table 2. Total length (TL) of captured blue sharks. - = missing data, Min = Minimum, Max = Maximum, SD = standard deviation.

Blue sharks catch	n	Min. and Max.	Mean length (SD)	Sex ratio
		TL		(% of males)
Total caught individuals	1 076	70 to 240 cm	-	-
Individual caught by hooks	94	100 to 200 cm	109 (18) cm	52%
equipped with magnets inside the				
zones 1, 2 and 3				
Individual caught by control	75	100 to 200 cm	112 (15) cm	55%
hooks inside the zones 1, 2 and 3				
Individual caught by hooks	907	100 to 200 cm	-	77%
without magnets in the zone 4				

Table 3. References concerning tests of electropositive and magnetic effects on sharks in laboratory (Lab) and field.

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Dispositive Control Prionace glanca NdFG N35 - NdNi X35 Field no This study Sphyrna mokarran BaFel 2019 Lab yes O'Connell et al., 2014 Neggprion brevirostris BaFel 2019 Lab yes O'Connell et al., 2014 Scytorhims cancula Nd2Fel 4B Lab yes Smith and O'Connell, 2014 Carcharbar scanthias BaFel 2019 Field yes O'Connell et al., 20144 Ambbragia raditata Electropositive metal Field yes O'Connell et al., 20144 Ambbragia raditata Electropositive metal Field no O'Connell et al., 20144 Prionace glauca Electropositive metal Field no O'Connell et al., 2013 Carcharhinus limbatus Neodymium (Nd) metal Lab no McCutcheon and Kajiura, 2013 Sphyrna tiburo - group Neodymium (Nd) metal Lab no McCutcheon and Kajiura, 2013 Prionace glauca Electropositive metal Field no Godin Cosandey et al., 2013 Sphyrna tiburo - group Neod	Species	Electromagnetic	Study	Detterent	References
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Squalus acanthias	Neodymium (Nd) metal	Lab	yes	Jordan et al., 2008
Mustelus canis	Neodymium (Nd) metal	Lab	yes	Jordan et al., 2008
Carcharhinus galapagensis	Electropositive metal	Field	yes	Wang et al., 2008
Carcharhinus plumbeus	Electropositive metal	Field	yes	Wang et al., 2008
Negaprion brevirostris	Electropositive metal	Field	yes	Rice, 2008
Carcharhinus galapagensis	Neodymium (Nd) metal	Field	no	Robbins et al., 2008
Carcharhinus galapagensis	PrNdA	Field	no	Robbins et al., 2008

429 Figure legends

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Figure 1. Map of the marine area (northeastern Atlantic) and location of the fishing zone(black oval) where magnet experiments were conducted.

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Figure 2. a. Position of the magnet model 2 with a hook under real fishing conditions.
Photo: Sebastián Biton Porsmoguer. b. Position of magnet model 2 on a hook measured
for magnetic field in laboratory. Photo: Christophe Almarcha.

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Figure 3. Position of hooks with magnet models 1, 2 and control hooks in thetestedzones 1, 2 and 3. The rest of the longline was the zone 4.

Figure 4. Measurement of the maximum magnetic field B in tesla (T) along the distance
X in cm for a hook filled with, respectively, big magnet for model 1 (big black circles),
small magnet for model 2 (small grey circles), a hook alone after contact with big
magnet model 1, a hook alone after contact with small magnet model 2 and a hook
alone which was never in contact with a magnets (white circles), in a log-log scale.

Figure 5. A blue shark *Prionace glauca* caught by the longline vessel during the fishing
campaign. Photo: Sebastián Biton Porsmoguer.

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Figure 6. Comparison of the CPUE (catch per unit of effort) with mean values for blue shark (*Prionace glauca*) between the two model of magnets (M1 = model 1, M2 = model 2) and the control hooks inside the tested zones.

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24 Figure 5.



