SCRS/2004/104

TAGGING-RECAPTURE ACTIVITIES OF LARGE PELAGIC SHARKS CARRIED OUT BY SPAIN OR IN COLLABORATION WITH THE TAGGING PROGRAMS OF OTHER COUNTRIES

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Abstract.

This paper presents the tagging and recapture activities directed at pelagic sharks under the Tagging Program of the IEO (TP) during the 1984-2004 period. This includes data on individuals tagged and recaptured by our TP as well as sharks tagged by foreign laboratories and later recovered and reported through our TP. A total of 2435 sharks were recaptured, 2208 of which were sharks tagged by other countries. A total de 154 recaptures came from 4662 sharks released during opportunistic tagging activities carried out on board Spanish longliners, while 73 recaptures were from 918 sharks released during two scientific tagging surveys conducted in the North Atlantic areas. Recapture rates were 3.3% and 7.9 %, respectively, depending on the type of tagging done. The longest periods at large were 3847 and 3843 days for species Isurus oxyrhinchus (IOO) and Prionace glauca (PGO), respectively. The results would suggest that there are migratory patterns partially dependant on the tagging strategies used by the different countries and on the spatial and temporal pattern of the fishing effort carried out by the fleet reporting the recaptures. The overall recaptures show that the two species move over a wide range, but no transoceanic movements were detected. This would suggest that movements are limited to within each hemisphere. PGO data from the North Atlantic indicate that these sharks migrate between temperate and warm-water zones, with an apparent border curbing these migratory movements around regions of the Equator. Aspects related to the standardisation of the tagging-recapture protocols used by the different countries are also discussed.

Resumen.

Se presentan las actividades de marcado y recaptura de varios tiburones pelágicos realizadas por el Tagging Program del IEO (TP) durante el periodo 1984-2004, tanto para los individuos marcados y recapturados por nuestro TP como para aquellos tiburones marcados por laboratorios extranjeros posteriormente recapturados y comunicados a través de nuestro TP. Un total de 2435 tiburones fueron recapturados, de los cuales 2208 eran tiburones marcados por otros países. Un total de 154 recapturas proceden de 4662 tiburones liberados durante las actividades de marcado oportunista realizadas a bordo de palangreros españoles y 73 recapturas proceden de 918 tiburones liberados durante dos campañas científicas de marcado realizadas en el Atlántico Norte. Las tasas de recaptura fueron 3.3% y 7.9 %, respectivamente, según el tipo de marcado efectuado. Los mayores tiempos en libertad comunicados fueron de 3847 y 3843 días para las especies Isurus oxyrhinchus (IOO) y Prionace glauca (PGO), respectivamente. Los resultados sugieren patrones migratorios en parte dependientes de las estrategias de marcado usadas por cada país y del patrón espacio-temporal de esfuerzo de pesca aplicado por la flota que comunica las recapturas. El conjunto de las recapturas muestra amplios movimientos para ambas especies sin llegar a detectarse movimientos transoceánicos y sugieren migraciones restringidas dentro de cada hemisferio. Los datos de PGO a nivel del Atlántico Norte sugieren migraciones entre zonas templadas y entre zonas templadas y cálidas, con una aparente frontera en sus movimientos migratorios a nivel de las región ecuatorial. Se discuten además aspectos relacionados con la recomendable normalización de los protocolos de marcado-recaptura usados por los diferentes países.

Key words: large pelagic sharks, tagging, recapture, behaviour, migrations.

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1. Introduction.

The large pelagic tagging programs conducted by the Instituto Español de Oceanografía IEO (Spain), using traditional tags, began in 1976 directed at different tuna species (CORT 1989). The scope of this objective was later broadened to cover other large pelagic oceanic species including the Xiphioidei and the large pelagic sharks. The tagging program carried out on the latter species by the IEO (TP) includes both scientific tagging surveys and opportunistic tagging done by scientific observers on board commercial longliners, taking advantage of the live individuals caught, in addition to the tagging-release of fishes by the Spanish surface longline fleet itself, whose crews began tagging swordfish voluntarily in 1981 (MEJUTO 1991, GARCÍA-CORTÉS *et al*. 2000, 2003). In 1985 our TP was extended to the tagging of sharks and Istiophoridae, which are by-catches of this fishery. The purpose of these programs was to gain knowledge of these species and broaden the scope of the tagging activities started in the 1970s by several countries(CASEY 1985).

One of the most important aspects of tagging programs on a national level, and especially on an international level, is the availability of the appropriate resources to be able to recover the tags. In this sense, it is essential to have an adequate advertising system (HOLT 1963) as well as a reward system or lottery to improve the returns of tagged fish (HYLEN 1963). However these systems and rewards for recovering traditional tags are not properly standardised among the different countries, which gives rise to feelings of animosity among the crews, depending on the type of tag recovered, the tagging country, the species recaptured, etc., occasionally leaving the laboratories to deal with unpleasant situations when contacting the fishermen reporting these recaptures. In any case, the complex relationship between fishermen and scientists is usually more important than the rewards promised, at least in many countries where the rewards for recovering traditional tags are merely symbolic.

Thanks to the close communication and collaboration between the scientist and the Spanish surface longline fleet maintained over the course of decades, great progress has been made in the number and quality of the recovery of fishes tagged and released, among other aspects, under the programs conducted by Spain or other countries, with whom Spain has close ties through their respective research laboratories.

Tagging fishes with traditional tags is a method used to gain insight into migrations, to make estimations of mortality and survival rates, and in some cases, to assess the population size or applied to growth and validation studies. Moreover, it is a tool regularly used in conjunction with other methods, such as electronic tagging, genetic techniques, etc., in stock structure research. Traditional tagging has long-term advantages over other techniques, but it also has its limitations. Both pros and cons should be taken into consideration when planning experiments and analysing the results obtained from traditional tagging.

The main objective of this paper is not to conduct an in-depth exploration of all the available sources of information collected over decades of collaboration with the fleets and different national and international research centres. In our opinion, a comprehensive exploration of all the data would require projects to be started that would allow for the joint analysis of the huge effort that has been made by many different scientists and laboratories from a number of nations for decades. This paper merely attempts to summarise the progress made and the information collected under our TP (up until February, 2004) in terms of the volume of sharks tagged by the IEO tagging program (Spain), to supply information on the total number of recaptures obtained, in most cases reported by the Spanish surface longline fleet to foreign laboratories, and to venture a diagnosis and open up discussions that will serve to orient future joint studies. Only 8 recaptures of fishes tagged by our TP were later recaptured and reported by the fleets of 5 other countries, which would imply that there is a low reporting rate in other fleets if we observe the fishing effort applied.

2. Material and methods.

Recapture data were obtained on the basis of information provided by skippers, shipowners, sailors and associations belonging to the Spanish surface longline fleet with whom there has been direct communication for decades. Thanks to these joint efforts a more reliable information has been obtained and disseminated, and it is the crews who make up the real "heart" of the tagging program. A system of token rewards was set up and standardised. In addition, the protocol was perfected and made easier in terms of both recovering the recaptures and getting the tagging information back to the crew who recovered the fish. This last aspect has been afforded special importance, as it is possibly the most fulfilling incentive for the crews.

The batches of tags used for opportunistic tagging during commercial trips also include forms where all the data on the tagging and release of each fish must be filled in. These batches of tags are given to the skipper of the

vessel personally, or to the observer, with both written and oral instructions. After the tags from the batch have run out, the forms including all the release data on the fishes (species, date, location, size/weight-type, sex, gear, fish condition, tagger's name and address, etc.), must be returned. The information received is quality controlled and then entered into a database.

Recapture information is usually reported by the skippers when they arrive at port, but more commonly it is reported at sea, which allows for the collection of excellent quality data when the vessel arrives at port. For this purpose, forms have been handed out along with their different material with information on the procedures to be followed, including photographs of the most common types of tags found in the recaptures (photograph 1), information on electronic tags, etc.

The type of traditional tags used in this IEO tagging program (TP) on these shark species has changed very little over the years. In the beginning sharks were tagged with Type D spaghetti tags used for the swordfish. First, a small incision was made in the skin with the tip of a knife and then the tag was inserted. Later on, Type H tags were used almost exclusively for these species (MATHER *et al*. 1974).

The tagging activities conducted under the TP may be classified into several categories. Scientific Tagging Surveys were carried out in 1997 and 1998 in the North East Atlantic (between 20º-40º N) aimed primarily at the swordfish. However, sharks were also tagged with tagging protocols that proved to be highly efficient in all the species released (GARCÍA-CORTÉS *et al*. 2003). Unfortunately, owing to a lack of funds, these activities had to be suspended. Opportunistic tagging was also carried out since 1985 by the Spanish surface longline fleet as well as by observers on board commercial vessels taking advantage of some of the live individuals caught, which has produced a considerable number of tagged and released sharks.

Records were previously identified by country, tagging method, tag type, species, year, ocean, etc., to estimate respective recapture rates. These recapture rates were estimated in % on the basis of the number of individuals tagged and their respective recapture levels. More specifically, the recapture rates were calculated with the two methods of tagging used by our TP, opportunistic tagging aboard commercial fishing vessels and the tagging cruises-surveys, the latter being interpreted as the recapture rate obtained in the scientific tagging surveys. The total recapture rate was obtained by summarising the recaptures resulting from the two methods of tagging.

For descriptive purposes, the total number of foreign recaptures was calculated by species, year, tagging laboratory or country, all of which were reported to the respective foreign laboratories that had done the tagging.

The species codes used in this paper are as follows: ASO: *Alopias superciliosus*. AVO: *Alopias vulpinus*. CAO: Carcharhinus sp.. CFO: *Carcharhinus falciformis*. CLO: *Carcharhinus longimanus*. CPO: *Carcharhinus plumbeus*. CRO: *Carcharhinus brachyurus*. CSO: *Carcharhinus signatus*. GCO: *Galeocerdo cuvier*. IOO: *Isurus oxyrhinchus*. IPO: *Isurus paucus*. LNO: *Lamna nasus*. PGO: *Prionace glauca*. PKO: *Pseudocharcharias kamoharai*. SLO: *Sphyrna lewini*. SPO: Sphyrna sp.. SZO: *Sphyrna zygaena.*

The size of the sharks was either measured to the lowest centimetre or estimated using the distance from the tip of the snout to the fork of the tail –fork length- (FL). However, the size of most of the specimens tagged or recaptured by other countries has originally been reported in total length –to the tip of the caudal fin- (TL). All length data are expressed in terms of fork length (FL) in this paper. When size was originally reported as total length (TL) the size was converted to fork length (FL) by means of the following relationships:

Prionace glauca (PGO) FL= -1.061 + 0.8203 * TL (CASTRO & MEJUTO 1995).
Isurus oxyrhinchus (IOO) FL= - 1.7101+ 0.9286 * TL (CASEY & KOHLER 1992).

In the other species size conversions were not carried out since very few individuals were recaptured with complete information on tagging and recapture. The graph depicting size frequency in tagging and recapture was drawn up by previously grouping the observations into size intervals of 5 cm.

Locations of tagging and recaptures of the most important species in number of individuals released and recovered by our TP were grouped in 5ºx5º squares for descriptive purposes. The movements carried out are presented in the graph, assuming that the movement and distance covered is rectilinear between the points of release and recapture.

When the recapture position is near the tagging location, it is only possible to represent one point on the map and its movement cannot be depicted. When a position appears on land, this means that the exact position of capture

of this specimen is unknown, although it is possible to locate the 5ºx5º square where the individual was recaptured. In this case, the geographic position of this observation is allotted to the vertex of the square according to the standard criteria by quadrant adopted by the ICCAT (MIYAKE 1990).

In order to make a qualitative evaluation of the available size data, linear relations were tested between the size increments and the time at large, in addition to the growth rate and mean size between the tagging and recapture size (GULLAND 1971).

3. Results and discussion.

The types of tags used (MATHER *et al*. 1974) on the total number of sharks released by Spain under the TP were the H type (64%), D type (31%) and M type (5%). The ratio of recaptures with these tags were as follows: H type (6%), followed by the M type (3%) and D type (1%). These results would suggest that the three tag types were similar in efficiency. The type of tags used by other countries and recovered by the Spanish fleet were mostly of the M type (72%), both Jumbo types (27%), D type (0.5%) and N type (0.3%), (photograph 1).

During the Scientific Tagging Surveys conducted in 1997 and 1998 a total of 918 sharks were tagged in the North East Atlantic (table 1) of which 73 individuals have been recovered (table 2, figure 1). For the total number of sharks, the recapture rate was 7.95 %.

The opportunistic tagging carried out by on-board observers as well as by the commercial fleet between 1985 and February, 2004, was completed with a total of 4662 sharks tagged and released (table 3, figure 2), nearly 87% of which were released in the Atlantic, approximately 9% in the Indian ocean and 4% in the Pacific. Since 1986, 154 tagged sharks have been recovered from opportunistic tagging activities (table 4). The total recapture rate from the opportunistic tagging of all the sharks was 3.3%.

A total of 5580 sharks were tagged by Spain in the different oceans and years (table 5), 227 of which were recaptured (table 6, figures 3 and 4). Of these 227 recaptures, only 8 were reported by other countries as being recaptures of their fleets, which would imply that the reporting rates from other countries are quite low in spite of the fishing effort applied by these fleets. The overall recapture rate of the total number of sharks tagged by Spain was 4.07%. The recapture rate varied depending on the species and tagging method used (table 7).

Taking into account only the tags used by foreign laboratories between 1984 and February 2004, a total of 2208 sharks have been recaptured and reported. These animals had been previously tagged and released under the tagging programs conducted by other countries (table 8). Most of the recaptures carried out by the Spanish fleet pertained to fishes tagged by the National Marine Fisheries Centre (USA) with a total of 1463 sharks recaptured, and by the Central Fisheries Board of Ireland with a total of 562 recaptures (table 9). For all the tagger countries combined, the total number of sharks recaptured by the Spanish surface longline fleet amounted to 2435 individuals, which had been tagged and released either by Spain or other countries (table 10, figure 5).

After examining the available data on the most prevalent species in the recaptures (PGO and IOO) in both the time of release and recapture, it can be seen that size data are only available for 829 specimens of PGO and 89 specimens of IOO. For PGO, 17% of the individuals showed a negative size increase during their time at large, only one individual (0.1%) did not change in size and roughly 83% positively increased in size. For IOO, 15% showed negative size increases and 85% exhibited positive increments in size. Some of these records were later omitted because of obvious inconsistencies in data. A total of 688 entries of PGO and 76 IOO were finally considered as potentially useful data for preliminary descriptive purposes.

The size frequency of the tagged and recaptured fishes of both species PGO and IOO is broad in scope, ranging from juveniles to large adults (figure 6). The largest-sized sharks recaptured from both species were a PGO measuring 400 cm FL and an IOO of 314 cm FL, the latter being questionable as to the type of size reported.

The analysis of size increments *versus* time at large, for the two species under consideration, would suggest that the relationships between the two variables have positive slopes, although for PGO the data are highly dispersed (figure 7). The preliminar analyses of growth rates relative to the mean size between tagging and recapture would generally point to unsatisfactory regressions, possibly suggesting that size information is quite inconsistent in many of the records. Therefore for the future works in-depth exploration of these data it would be advisable to test methods that would restrict growth rates to within biologically realistic ranges for these species and to eliminate possible out-layers before tackling growth or validation studies (figure 8). In these shark

species, the tagging size is often difficult to determine or is estimated during fishing operations, without the fishes being able to be hauled on board after they have reached certain size ranges. This means that many of the size recordings are mere approximations. On the other hand, the recapture sizes are usually more reliable if the specimens are examined by trained people. Also, the original records may be estimated based on different types of sizes and/or weights, depending on the country, which is often poorly specified, making it even more difficult to get an accurate estimate of size increments over time.

The data of movements of several species of Carcharhinus (CAO, CLO and GCO) would suggest that these animals cover a wide range, while the other species (ASO, CFO, CRO) show more restricted movements. The CLO species exhibits a trans-equatorial migration in the Indian ocean. This is not surprising in this ocean which lacks a North system. As regards the CRO species, although only one arrow is visualised in the figure, it really depicts two individuals, both of which were tagged and recaptured in the same positions (figure 9).

Data on the total number of fishes tagged by Spain under its TP (by square) in addition to the recaptures obtained by the Spanish fleet under all the international tagging programs for species LNO, IOO and PGO are given in figures 10, 11 and 12, respectively. Tagged individuals of LNO generally fit the expected distribution areas for this species, being present in the high latitude regions in both hemispheres (COMPAGNO 1984). There was, however, one observation in the Gulf of Guinea, whose original data had to be changed as the individual was really a specimen of IOO which had been reported under its common/local name and incorrectly coded.

The broad areas tagged by the Spanish fleet under the TP show the spatial coverage for species IOO and PGO, in an attempt to cover most of the fishing zones of this fleet. However, the tagging level we were able to achieve under our TP was greater in scope in the North Atlantic areas, since the traditional North Atlantic fleet began collaborating decades ago and the contacts maintained are more frequent and open. In the Indian and Pacific Oceans this activity is even more reduced since the fisheries were started more recently. Practically all of the recaptures of the two species come from the North Atlantic since this is the hemisphere where the international tagging effort has been concentrated as a result of the tagging programs maintained by different countries in this hemisphere. In contrast, in the southern hemisphere the tagging programs are less familiar, more recent and carried out on a smaller scale.

The movements assumed to be made by the species IOO and PGO on the basis of recaptures obtained by the Spanish fleet under international tagging programs with available recordings of tagging and recapture positions are shown in figures 13 and 14. An additional record of a PGO tagged by Japan in the Indian Ocean and recaptured in the vicinity of Australia was not able to be positioned on a map due to the fact that it was impossible to recognise the tag number. The largest rectilinear movements observed accounted for 3898 miles for a period of 668 days and 3942 miles for 986 days for species IOO and PGO, respectively.

In general IOO and PGO data in the Atlantic would indicate that their migration is restricted to within each hemisphere or in the vicinity thereof, with generally no trans-equatorial migration being seen until they approach the equatorial limits. In spite of the high number of PGO individuals tagged in the North Atlantic by several countries, it is perceived as a geographic border at the level of the Equator, with the fishes moving between temperate zones and warm-tropical zones and viceversa. The latter movements could be related to the reproductive processes of this species (MEJUTO *et al*. in press). The fishing effort of the international fleets in the South Atlantic should not be overlooked so, either there is very little mixture between the North and South Atlantic or the reporting rate of tags in the South Atlantic is much lower than in the North, which is highly unlikely, at least as far as the Spanish fleet is concerned. In this sense, the recaptures obtained and reported by other fleets fishing in regions of the south Atlantic, especially those associated with the current of Brazil, could be of help in clarifying this issue.

Recaptures of PGO individuals tagged by Spain under its own TP show highly variable movements in the Atlantic (figure 15 a). However, recaptures of PGO obtained by Spain but tagged by other countries, specifically those tagged by Ireland (Lab. CFBI: Central Fisheries Board of Ireland) and by USA (Lab. NMFS: National Marine Fisheries Service), generally exhibit repetitive patterns. The specimens tagged in the NW Atlantic by USA in latitudes of around 40º N indicate that movements occur preferentially in an E and SE direction (figure 15 b). In contrast, individuals tagged in the NE Atlantic by Ireland in latitudes of around 50º N point to preferentially W and SW movements (figure 15 c). In short, the movements observed may be distinctly conditioned by the spatial and temporal scheme of the tagging effort used in the respective tagging experiments as well as by the fishing effort exerted by the Spanish fleet in the North Atlantic according to zone and fishing season (MEJUTO *et al*. 2003).

An analysis of the tagging-recapture data would suggest that the migratory patterns observed could be due, to some extent, to the seasonality of the tagging seasons. In our TP, individuals are released throughout all the month of the years in relatively wide-ranging regions. However, the tagging programs conducted by Ireland and the USA are more seasonal, so that the 96.8% and 83.9% individuals recaptured by the Spanish fleet come from fishes tagged during the period from June to September, respectively (figure 16). These tagging activities are probably influenced by meteorological conditions, local abundance or the possibility of access to the fishery.

Most of the IOO recaptures showed broad movements for the different annual times at large defined (0-3+ years), with some specimens tagged in the West Atlantic recaptured near the Strait of Gibraltar (figure 17). The fish recorded with the greatest time at large was for 3847 days. The results suggest that there are wide-ranging movements even during the first year the fish is at large. Similar movements have been observed during greater at large periods. The 3 individuals recaptured in the Pacific Ocean were tagged in this same ocean by our TP, and later reported by the Chilean fleet.

Owing to the high number of recoveries of PGO it was advisable to use a greater number of annual ranges of time at large (0-7+ years) to facilitate the interpretation of the results (figures 18 y 19). The greatest time at large observed was 3843 days. Wide-ranging migrations were observed for at large periods of less than one year, generally between the E and W areas of the North Atlantic, where most of the releases have taken place, as well as between these two areas and the Central Atlantic. Some of the recaptures already show broad migrations from temperate zones until they reach as far as tropical-equatorial zones despite their short period at large. The results would recommend the use of ranges of time at large of less than one year in future analyses to be able to interpret the behaviour of this species on a monthly scale. Time at large periods of over one year (1-4 years) present a similar picture, although they would indicate a greater % of recaptures in the tropical zones than when at large periods of less than one year are analysed.

The migrations carried out by individuals of PGO by sex, with adult sizes ranging from 170-190 cm FL (figure 20) was also plotted. Most of these individuals released from both sexes exhibited similar patterns of movement. However, most of the individuals released by Ireland in the NE Atlantic at around 50º North latitude were females, which may be explained by the observations carried out in the past decades, which would suggest that most of the local availability of PGO off the British coast was reported to consist of females (STEVENS 1974). Adult individuals released by the USA in the NW Atlantic at around 40º latitude would suggest that males and females behave differently. The results presented here as a mere example suggest that it would be advisable to carry out analyses by size-age, sex and time at large.

The joint work carried out by scientists to interpret the available data from the different tagging programs on these species may present an exceptional opportunity to attain greater insight into the behaviour of these species, their spatial-temporal segregation and stock structure. On the other hand, the individual interpretation of the data provided by each national tagging program might lead to a limited view, suggesting behaviour that may not be generally applied to the population, since the results obtained from traditional tagging appear to be conditioned by the spatial-temporal pattern followed in each tagging experiment and by the spatial-temporal pattern of the fishing effort applied by the fleets reporting recaptures. The greatest possible diversification of the tagging areas and seasons would be highly recommendable, which is also applicable to these species of large pelagic sharks. A combination of traditional tagging techniques with electronic tagging and genetic studies, etc., could improve the interpretation of the behaviour of these species. Moreover, it would be advisable to standardise the protocols among countries to be able to obtain and report tagging-recapture data, establish standardised units of size and weight, etc., through the scientific recommendations by the different regional fisheries bodies- RFBs such as the ICCAT.

Acknowledgements.

We would like to thank all of the skippers and sailors of the Spanish surface longline fleet for their collaboration over the course of decades with the IEO TP on pelagic sharks. Special thanks to the staff of the IEO, Manuel Quintans for his efficient work during the 1997 and 1998 scientific tagging surveys and the improvements of the tagging protocols made, José Luis Torres who computerised the time series of tagging data and Isabel González and Ángel Fernández for their help in maintaining an open relationship with the crews involved in tagging and recaptures. We would also like to express our gratitude to other colleagues working on IEO Program 04 on large pelagic species in the different coastal laboratories for their work reporting the shark recaptures obtained in the different areas and fisheries. We are also grateful to Manuel Marín, José Lorenzo and Enrique Majuelos, and many others, for maintaining permanent contact with the fleet to improve reporting rates, as well as all the scientific observers working on the projects of the Instituto Español de Oceanografía SWOATL, SHKLL, and

SHKLL03for the opportunistic tagging carried out, as well as for their efforts in the providing the crew with training and sensitivity in tagging-recapture tasks.

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Table 1.. Number of pelagic sharks released during the scientific tagging surveys (1997, 1998) by species and year.

YEAR	SPECIES	No.Fish
1997	ASO	6
1997	GCO	1
1997	IOO	75
1997	PGO	515
1997	PKO	6
1997	SLO	1
1997	SPO	1
1997	SZO	1
1998	ASO	9
1998	IOO	8
1998	PGO	290
1998	SLO	5
TOTAL		**918**

Table 2. Number of pelagic sharks recovered from the individuals released during the scientific tagging surveys (1997-98) by species and year.

YEAR	SPECIES	No.Fish
1997	PGO	23
1998	IOO	1
1998	PGO	29
1999	ASO	1
1999	PGO	12
2000	ASO	1
2000	IOO	1
2000	PGO	4
2001	ASO	1
TOTAL		**73**

Table 3. Number of pelagic sharks opportunistically tagged and released by the Spanish fleet (1985-2004) by ocean and year.

YEAR	ATLANTIC	INDIAN	PACIFIC	TOTAL
1985	23			**23**
1986	60			**60**
1987	30			**30**
1988	3			**3**
1989	5			**5**
1990	30			**30**
1991	38		9	**47**
1992	120			**120**
1993	211	9		**220**
1994	281	59		**340**
1995	806			**806**
1996	711			**711**
1997	261			**261**
1998	507	29	5	**541**
1999	169	59	31	**259**
2000	195	1	68	**264**
2001	269	30	20	**319**
2002	203	35	16	**254**
2003	107	185	25	**317**
2004	15	37		**52**
TOTAL	**4044**	**444**	**174**	**4662**

Species	ATLANTIC	INDIAN	PACIFIC	TOTAL
ASO	7			**7**
AVO	1			**1**
CAO	40	10		**50**
CFO	76	71	8	**155**
CLO	172	56	1	**229**
CPO	4			**4**
CSO	5			**5**
GCO	3	2		**5**
IOO	1986	39	200	**2225**
IPO	7		3	**10**
LNO	74	7	2	**83**
PGO	1512	254	33	**1799**
PKO	23	3		**26**
SLO	2			**2**
SPO	1			**1**
SZO	58	2		**60**
TOTAL	**3971**	**444**	**247**	**4662**

Table 4 Number of pelagic sharks recovered from the individuals opportunistically tagged and released by the Spanish fleet, by ocean, species and year.

Species	ATLANTIC	INDIAN	PACIFIC	UNK	TOTAL
CFO	3	1			**4**
CLO	3	4			**7**
IOO	50		3		**53**
LNO	3				**3**
PGO	81	1		5	**87**
TOTAL	**140**	**6**	**3**	**5**	**154**

OCEAN	YEAR	SPECIES	No.fish	OCEAN	YEAR	SPECIES	No.fish
UNK	unk	PGO	5	**ATL**	2000	ASO	0
ATL	1986	IOO	1		2000	IOO	3
	1987	IOO	1		2000	LNO	1
	1990	CFO	1		2000	PGO	5
	1992	CFO	1		2001	ASO	0
	1993	CLO	2		2001	IOO	8
	1994	IOO	2		2001	PGO	10
	1995	CFO	1		2002	IOO	4
	1995	CLO	1		2002	PGO	8
	1995	IOO	2		2003	IOO	7
	1995	PGO	9		2003	LNO	1
	1996	IOO	13		2003	PGO	9
	1996	PGO	11		2004	PGO	1
	1997	IOO	4	**IND**	1994	CLO	3
	1997	PGO	15		1995	CLO	1
	1998	IOO	5		1998	CFO	1
	1998	LNO	1		2004	PGO	1
	1998	PGO	11	**PAC**	2000	IOO	1
	1999	ASO	0		2001	IOO	2
	1999	PGO	2	**ALL**	-	-	**154**

Table 5. Total number of pelagic sharks tagged and released by Spain (1985-2004), by ocean, species and year.

YEAR	ATLANTIC	INDIAN	PACIFIC	TOTAL
1985	23			**23**
1986	60			**60**
1987	30			**30**
1988	3			**3**
1989	5			**5**
1990	30			**30**
1991	38		9	**47**
1992	120			**120**
1993	211	9		**220**
1994	281	59		**340**
1995	806			**806**
1996	711			**711**
1997	867			**867**
1998	819	29	5	**853**
1999	169	59	31	**259**
2000	195	1	68	**264**
2001	196	30	93	**319**
2002	203	35	16	**254**
2003	107	185	25	**317**
2004	15	37		**52**
TOTAL	**4889**	**444**	**247**	**5580**

Species	ATLANTIC	INDIAN	PACIFIC	TOTAL
ASO	22			**22**
AVO	1			**1**
CAO	40	10		**50**
CFO	76	71	8	**155**
CLO	172	56	1	**229**
CPO	4			**4**
CSO	5			**5**
GCO	4	2		**6**
IOO	2069	39	200	**2308**
IPO	7		3	**10**
LNO	74	7	2	**83**
PGO	2317	254	33	**2604**
PKO	29	3		**32**
SLO	8			**8**
SPO	2			**2**
SZO	59	2		**61**
TOTAL	**4889**	**444**	**247**	**5580**

Table 6. Total number of pelagic sharks recovered from the individuals tagged and released by Spain (1986-2004) by ocean and year.

Species	ATLANTIC	INDIAN	PACIFIC	UNK	TOTAL
ASO	3				**3**
CFO	3	1			**4**
CLO	3	4			**7**
IOO	52		3		**55**
LNO	3				**3**
PGO	149	1		5	**155**
TOTAL	**213**	**6**	**3**	**5**	**227**

OCEAN	YEAR	SPECIES	No.fish	OCEAN	YEAR	SPECIES	No.fish
UNK	unk	PGO	5	**ATL**	2000	ASO	1
ATL	1986	IOO	1		2000	IOO	4
	1987	IOO	1		2000	LNO	1
	1990	CFO	1		2000	PGO	9
	1992	CFO	1		2001	ASO	1
	1993	CLO	2		2001	IOO	8
	1994	IOO	2		2001	PGO	10
	1995	CFO	1		2002	IOO	4
	1995	CLO	1		2002	PGO	8
	1995	IOO	2		2003	IOO	7
	1995	PGO	9		2003	LNO	1
	1996	IOO	13		2003	PGO	9
	1996	PGO	11		2004	PGO	1
	1997	IOO	4	**IND**	1994	CLO	3
	1997	PGO	38		1995	CLO	1
	1998	IOO	6		1998	CFO	1
	1998	LNO	1		2004	PGO	1
	1998	PGO	40	**PAC**	2000	IOO	1
	1999	ASO	1		2001	IOO	2
	1999	PGO	14	**ALL**	-	-	**227**

Table 7. Recapture rates of pelagic sharks obtained from opportunistic tagging, scientific tagging surveys and total tagging, carried out by our tagging program (TP) of Spain, by species.

OPPORTUNISTIC TAGGING		TAGGING SURVEYS		TOTAL TAGGING SPAIN	
Species	**Rec. Rate**	**Species**	**Rec. Rate**	**Species**	**Rec. Rate**
ASO	-	ASO	**20,000**	ASO	**13,636**
CFO	**2,581**	CFO	-	CFO	**2,581**
CLO	**3,057**	CLO	-	CLO	**3,057**
IOO	**2,382**	IOO	**2,410**	IOO	**2,383**
LNO	**3,614**	LNO	-	LNO	**3,614**
PGO	**4,836**	PGO	**8,447**	PGO	**5,952**
TOTAL	**3,303**	**TOTAL**	**7,952**	**TOTAL**	**4,068**

Table 8. Recaptures made by the Spanish fleet of pelagic shark species tagged and released from tagging programs conducted by other countries, during the 1984-2004 period.

Recaptures from sharks tagged for others countries	
CAO	3
CRO	2
GCO	7
IOO	205
PGO	1991
TOTAL	**2208**

OCEAN	YEAR	SPECIES	No.fish	OCEAN	YEAR	SPECIES	No.fish
UNK	-	PGO	63	**ATL**	1996	GCO	1
ATL	1984	IOO	1		1996	IOO	19
	1984	PGO	9		1996	PGO	107
	1985	IOO	2		1997	CAO	1
	1985	PGO	6		1997	GCO	2
	1986	IOO	5		1997	IOO	7
	1986	PGO	9		1997	PGO	195
	1987	PGO	3		1998	GCO	2
	1988	IOO	3		1998	IOO	16
	1988	PGO	8		1998	PGO	267
	1989	IOO	2		1999	IOO	15
	1989	PGO	10		1999	PGO	280
	1990	IOO	1		2000	IOO	9
	1990	PGO	22		2000	PGO	283
	1991	PGO	23		2001	IOO	25
	1992	IOO	8		2001	PGO	174
	1992	PGO	30		2002	IOO	14
	1993	IOO	4		2002	PGO	170
	1993	PGO	36		2003	CAO	1
	1994	IOO	21		2003	IOO	18
	1994	PGO	59		2003	PGO	133
	1995	GCO	1		2004	IOO	2
	1995	IOO	33		2004	PGO	10
	1995	PGO	93	**IND**	1999	GCO	1
	1996	CAO	1		2003	PGO	1
	1996	CRO	2	**ALL**	-	-	**2208**

Table 9. Number of pelagic sharks, by country and laboratory, tagged and released by other countries and recovered by the Spanish fleet, during the 1984-2004 period.

	COUNTRIES								
LABs	**CANADA**	**UK**	**IRELAND**	**JAPAN**	**NAMIBIA**	**S.AFRICA**	**USA**	**UNK**	**TOTAL**
St. ANDREWS	4								4
CFBI			562						562
GLASGOW MUSEUM		1							1
NMFS							1463		1463
NRIFSS				7					7
SAC G.B.		63							63
SEFC. MIAMI.							47		47
NSB						2			2
SFRI						1			
UK STP		6							6
NatMIRC					1				1
UNK								51	51
TOTAL	**4**	**70**	**562**	**7**	**1**	**3**	**1510**	**51**	**2208**

Table 10. Total number of pelagic sharks recovered by the Spanish fleet, from fish tagged-released by Spain and other countries during the 1984-2004 period , by species and ocean.

Species	ATLANTIC	INDIAN	PACIFIC	UNK	TOTAL
ASO	3				**3**
CAO	3				**3**
CFO	3	1			**4**
CLO	3	4			**7**
CRO	2				**2**
GCO	6	1			**7**
IOO	257		3		**260**
LNO	3				**3**
PGO	2076	2		68	**2146**
TOTAL	**2356**	**8**	**3**	**68**	**2435**

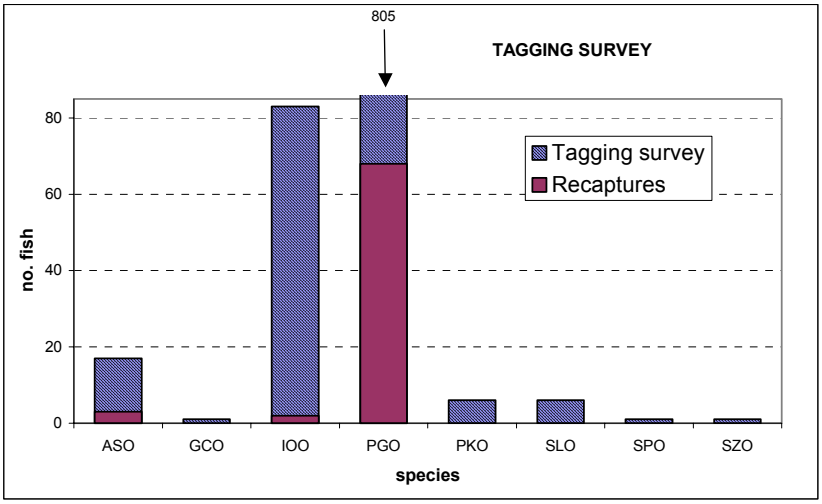


Figure 1. Number of individuals tagged by species (blue) and recovered (red) from the number of individuals tagged-released during the scientific tagging surveys carried out by Spain in years 1997 and 1998 combined. (please note the scale of tagged fishes has been cut for easier representation in graph form).

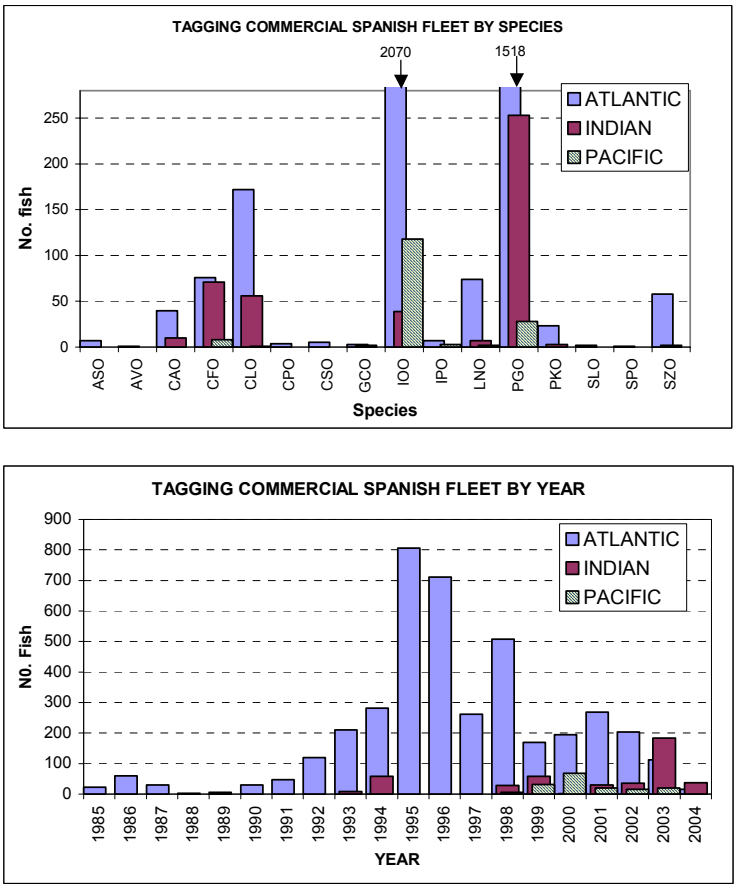


Figure 2. Total number of individuals tagged and released by Spain during the opportunistic tagging activities done between 1985-2004, by ocean, species and year (please note the scale of tagged fish by species has been cut for easier representation in graph form).

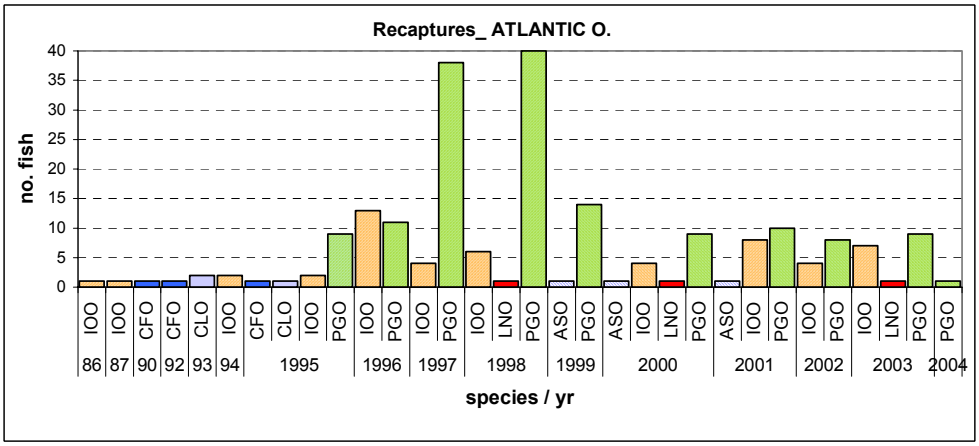


Figure 3. Total number of individuals recaptured by species in the Atlantic Ocean from individuals tagged and released by Spain during the opportunistic tagging activities and scientific tagging surveys, by species and year.

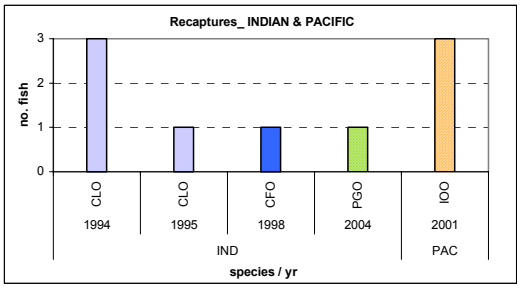


Figure 4. Total number of individuals recaptured by species in the Indian and Pacific Oceans from individuals tagged and released by Spain during the opportunistic tagging activities, by species and year.

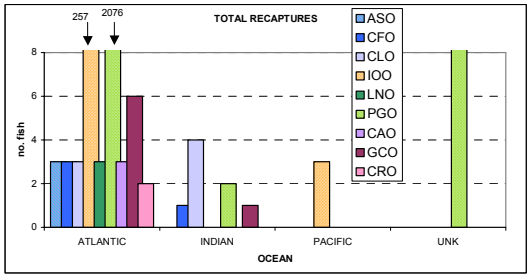
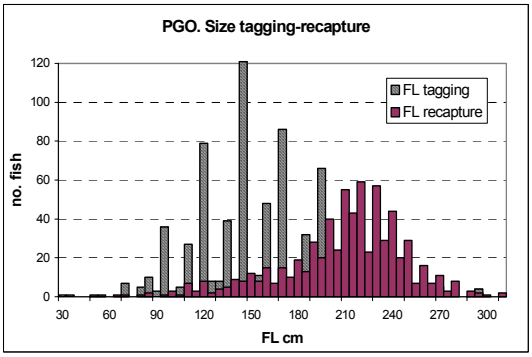


Figure 5. Total number of individuals recaptured by the Spanish fleet which had been tagged and released through tagging programs carried out by Spain and other countries, by ocean.



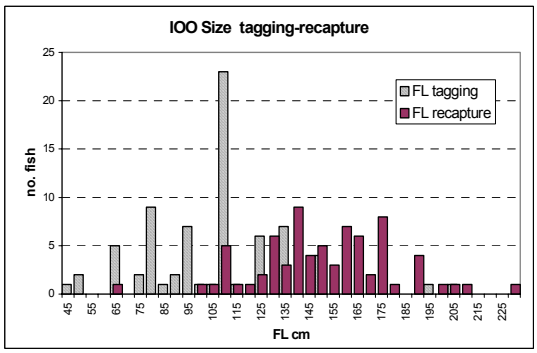


Figure 6. Number of individuals tagged and recaptured by size class, for *Prionace glauca* (PGO) and *Isurus oxyrinchus* (IOO) respectively.

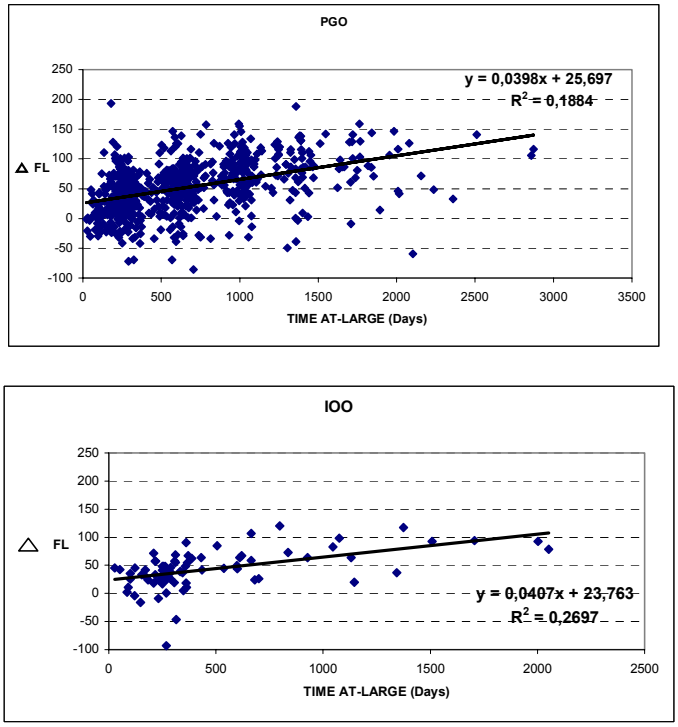


Figure 7. Regression between the size increase change (ΔFL = FL recapture – FL release) and days at-large, for PGO and IOO.

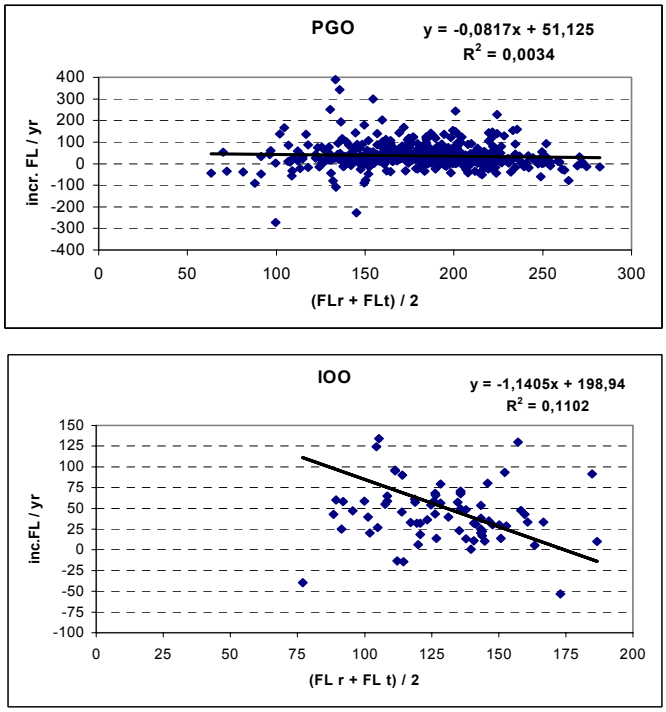


Figure 8. Annual growth rate *vs.* mean size between tagging and release, for PGO and IOO.

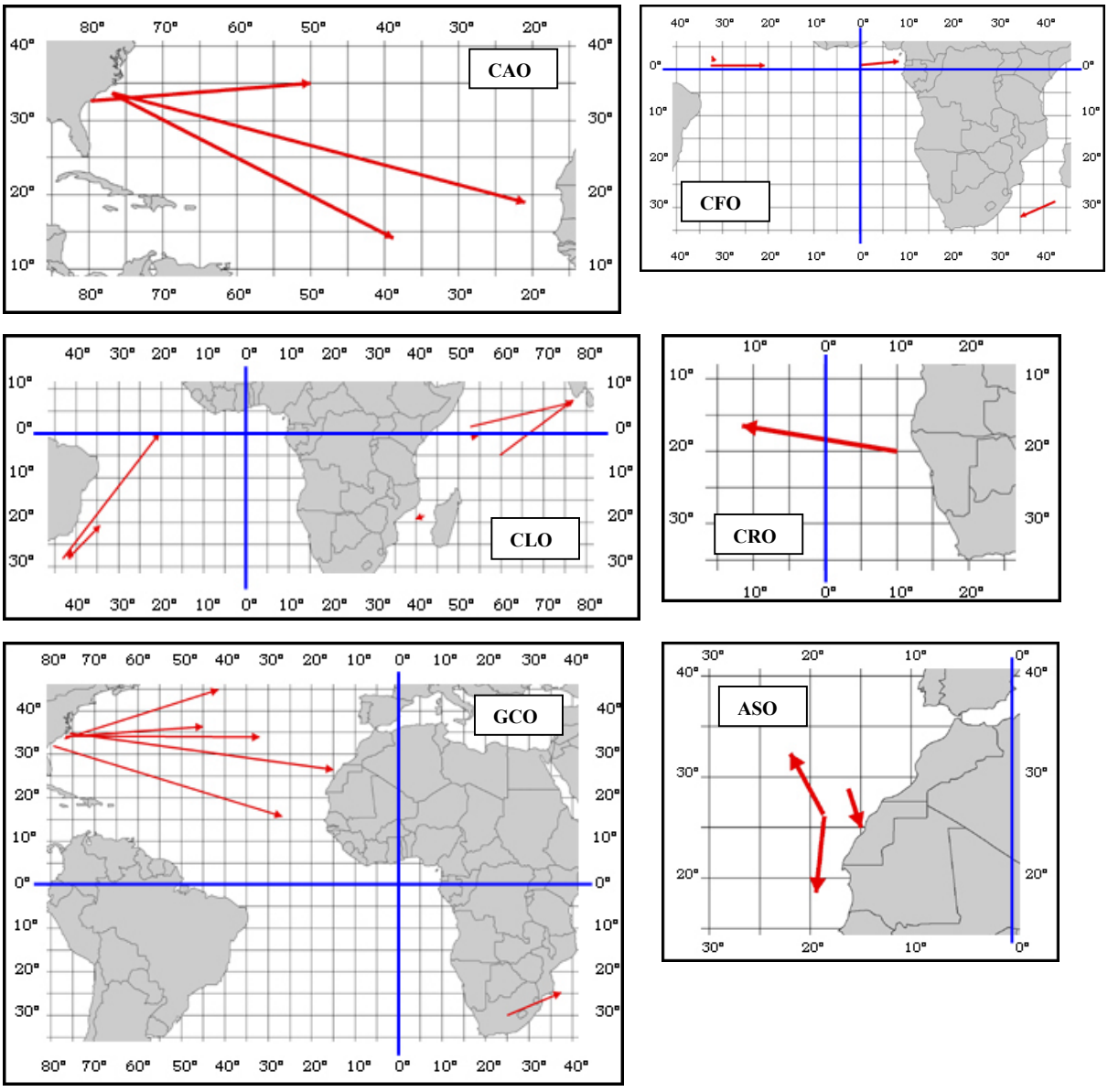


Figure 9. Rectilinear movements estimated on the basis of the tagging-recapture of different species of Carcharhinidae (CAO, CFO, CLO, CRO, GCO) and ASO, in the Atlantic and Indian Oceans.

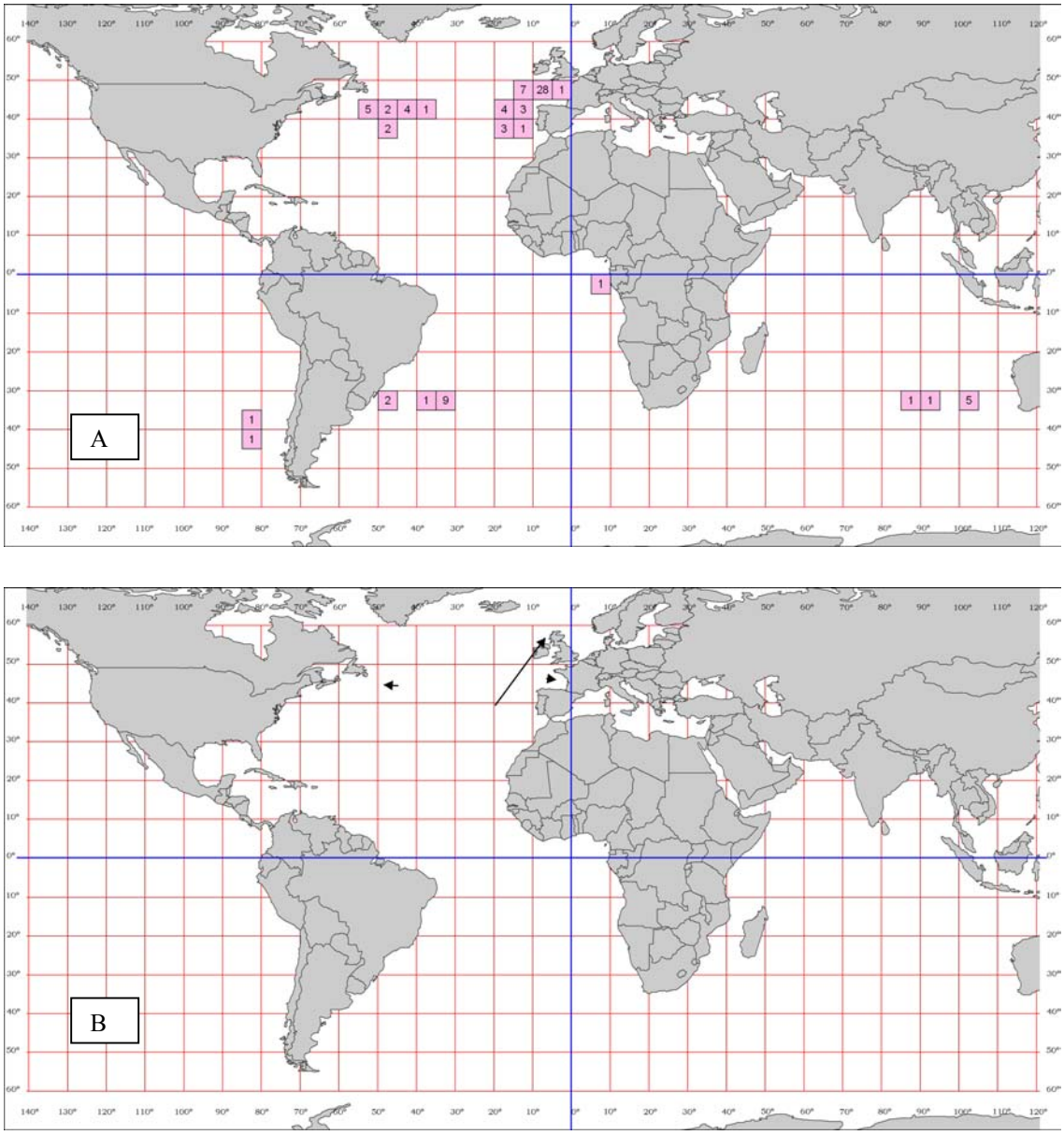


Figure 10. (A) Number of individuals of *Lamna nasus* (LNO) tagged and released by Spain, by 5x5 degree squares. (B) Rectilinear movements of the tagged-recaptured LNO obtained by the Spanish surface longline fleet.

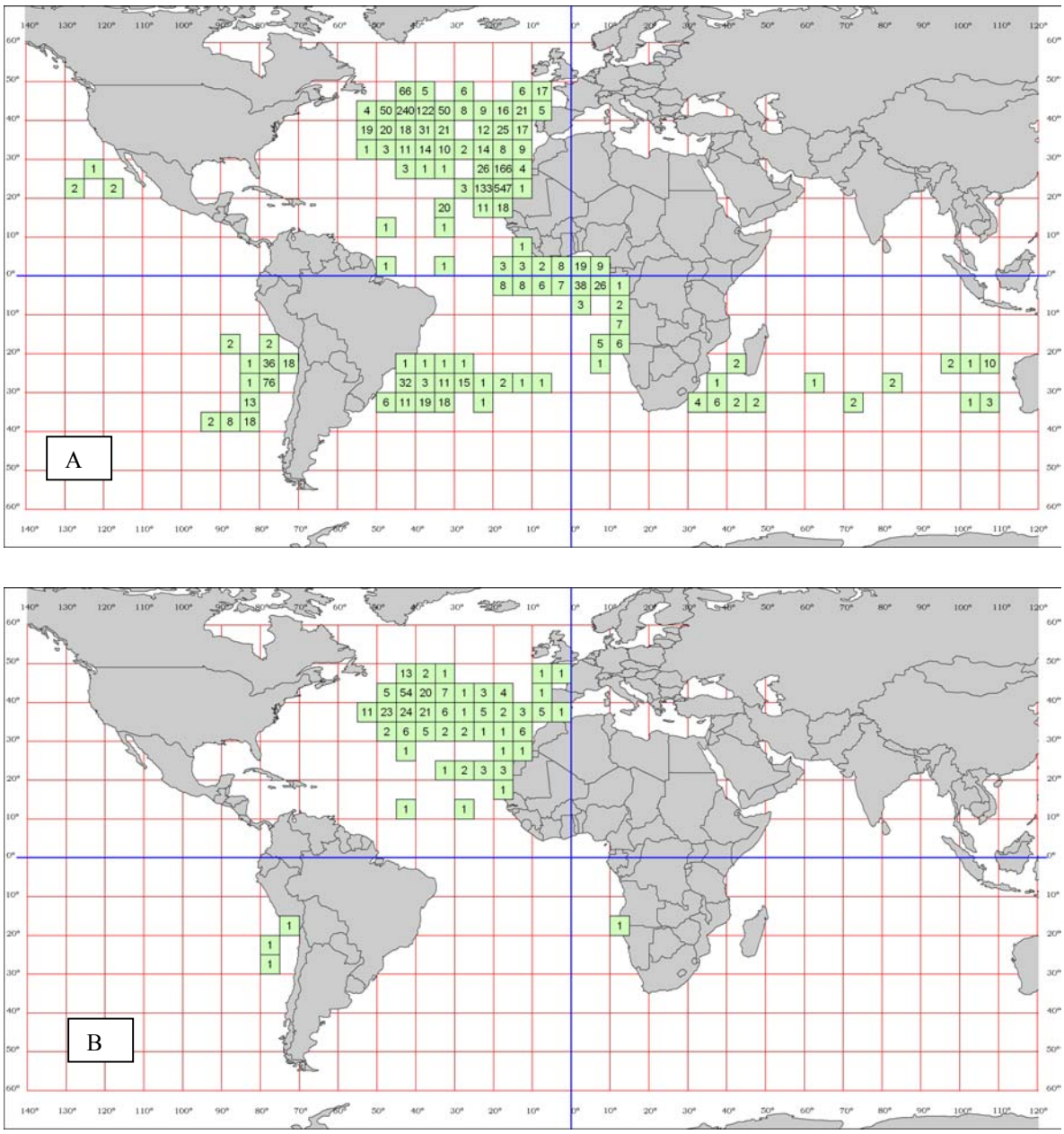


Figure 11. (A) Number of individuals of *Isurus oxyrinchus* (IOO) tagged and released by Spain by 5x5 degree squares. (B) Number of individuals of IOO recaptured by the Spanish surface longline fleet by 5x5 degree squares.

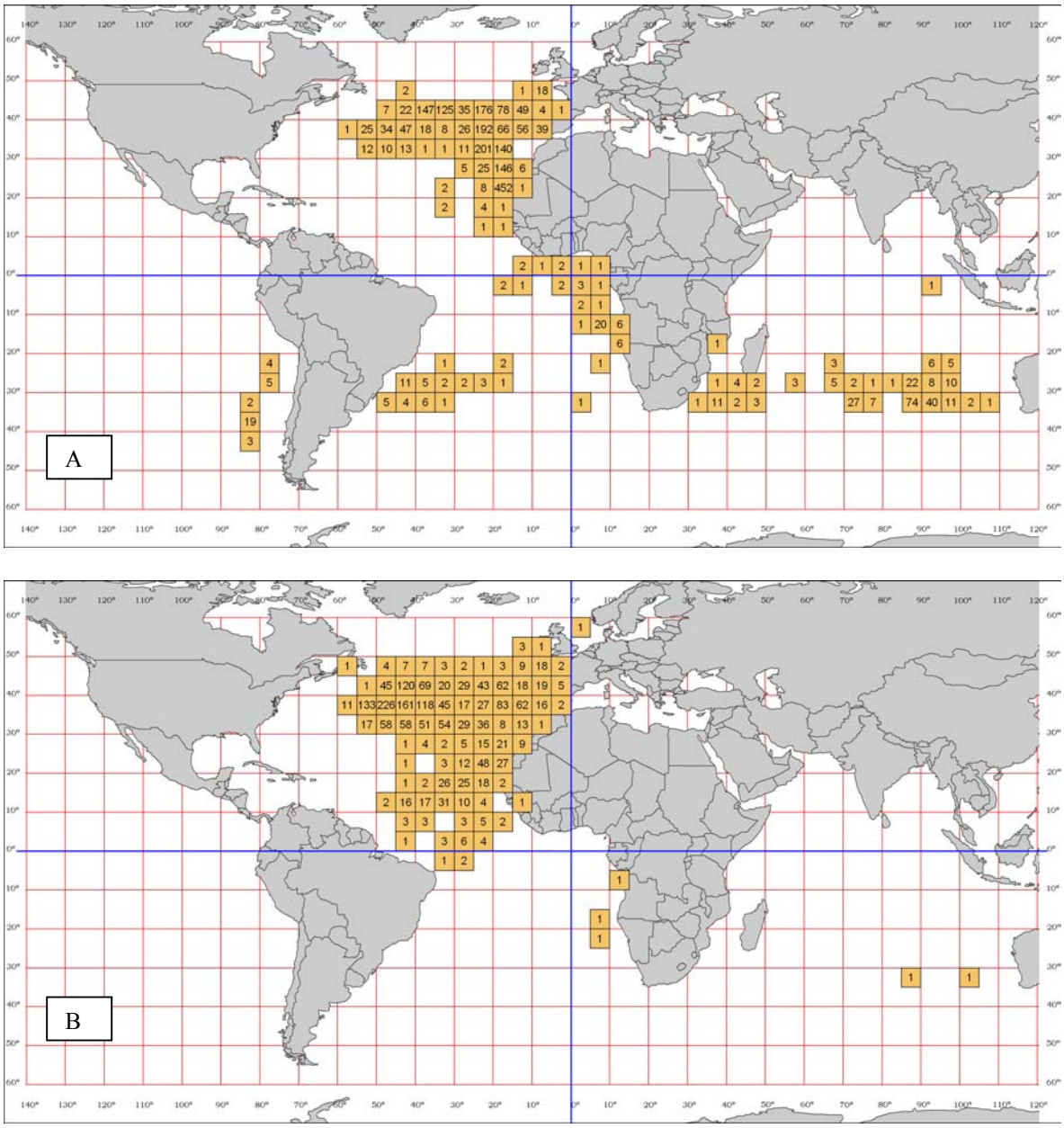


Figure 12. (A) Number of individuals of *Prionace glauca* (PGO) tagged and released by Spain, by 5x5 degree squares. (B) Number of individuals of PGO recaptured by the Spanish surface longline fleet by 5x5 degree squares.

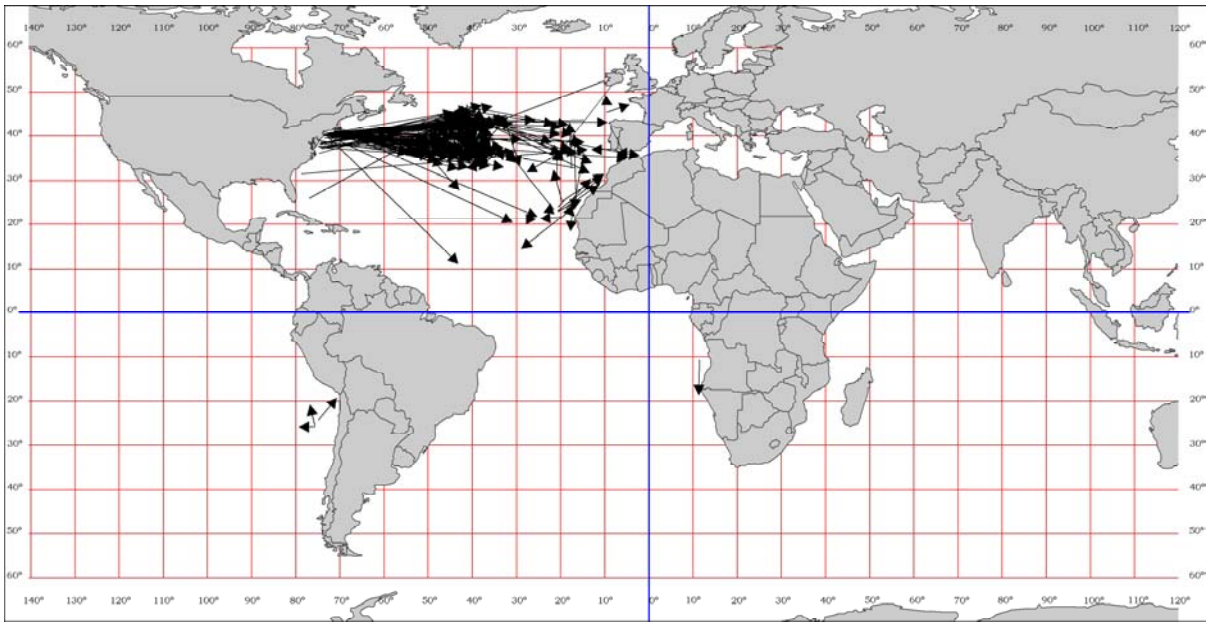


Figure 13. Rectilinear movements of the total number of individuals of *Isurus oxyrinchus* (IOO) tagged-recaptured in the Atlantic and Pacific Oceans.

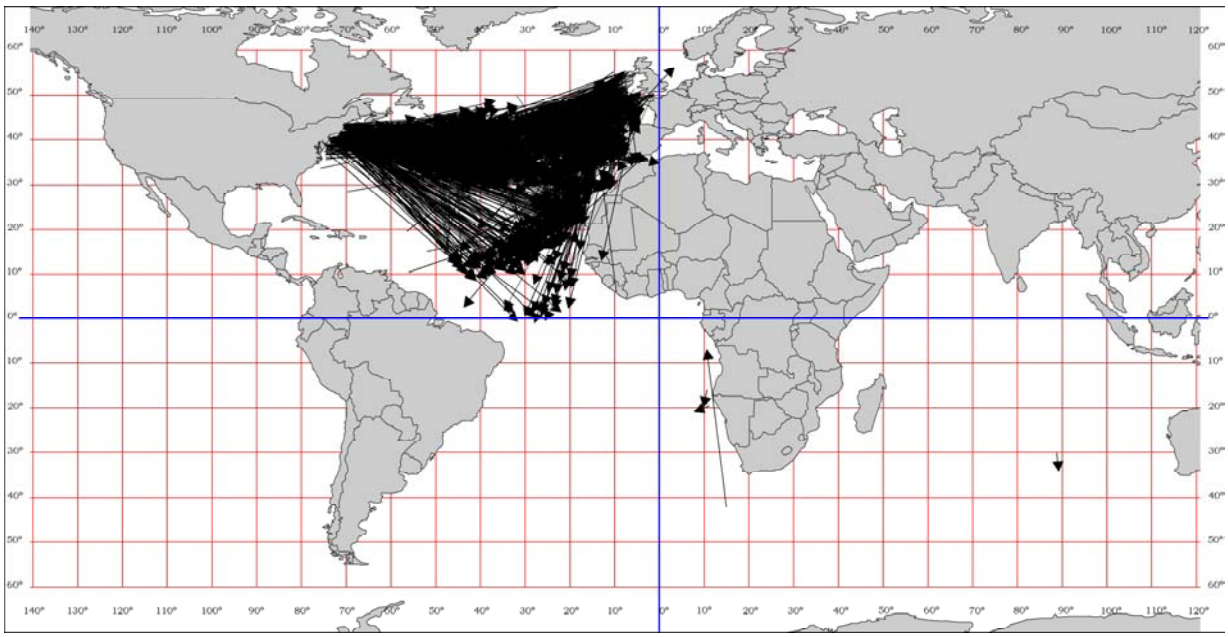


Figure 14. Rectilinear movements of the total number of individuals of *Prionace glauca* (PGO) tagged-recaptured in the Atlantic and Indian Oceans.

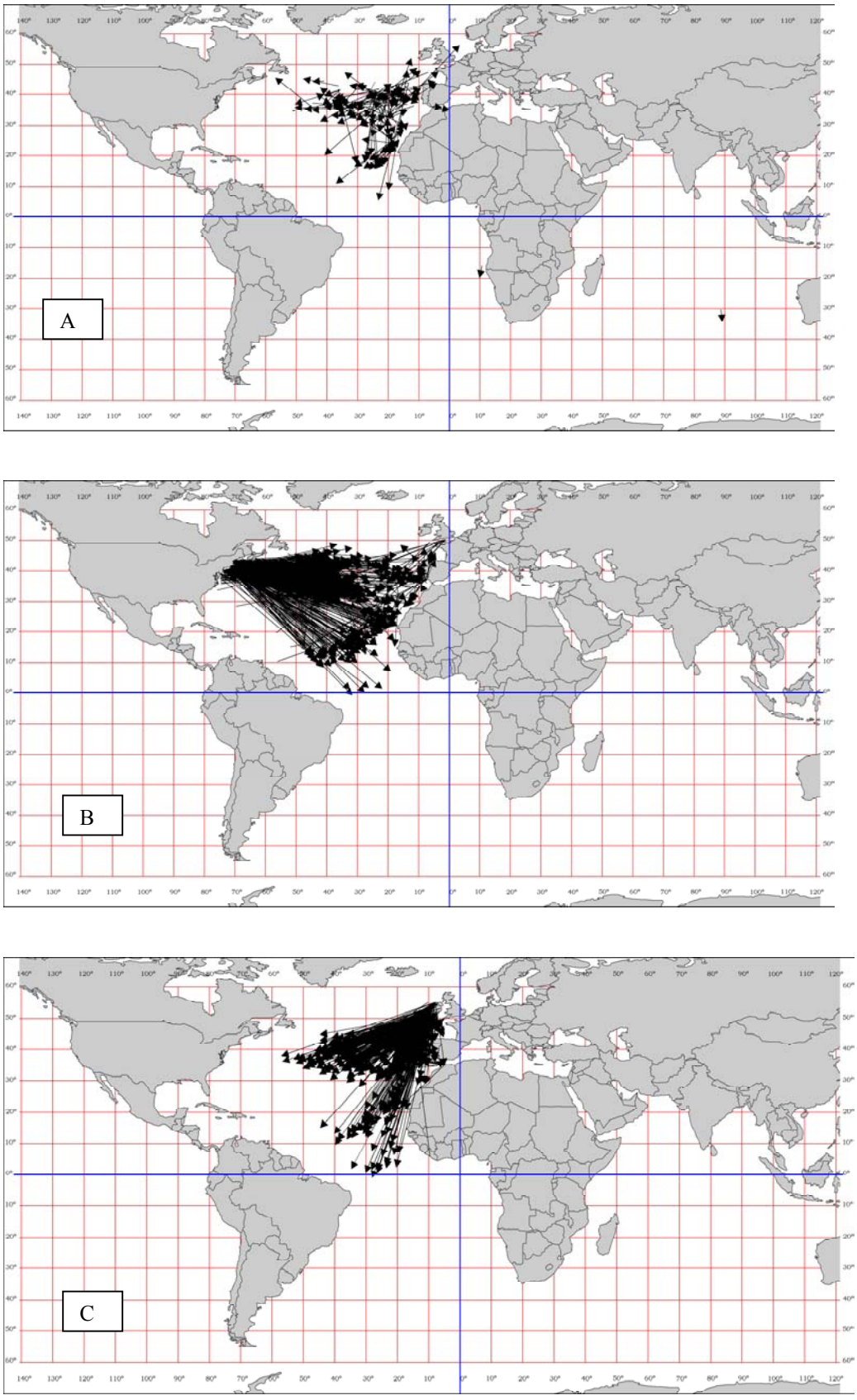


Figura 15. Rectilinear movements of the tagging-recapture of *Prionace glauca* (PGO), by laboratory and country. (A) Spain,. (B) USA, (C) Ireland.

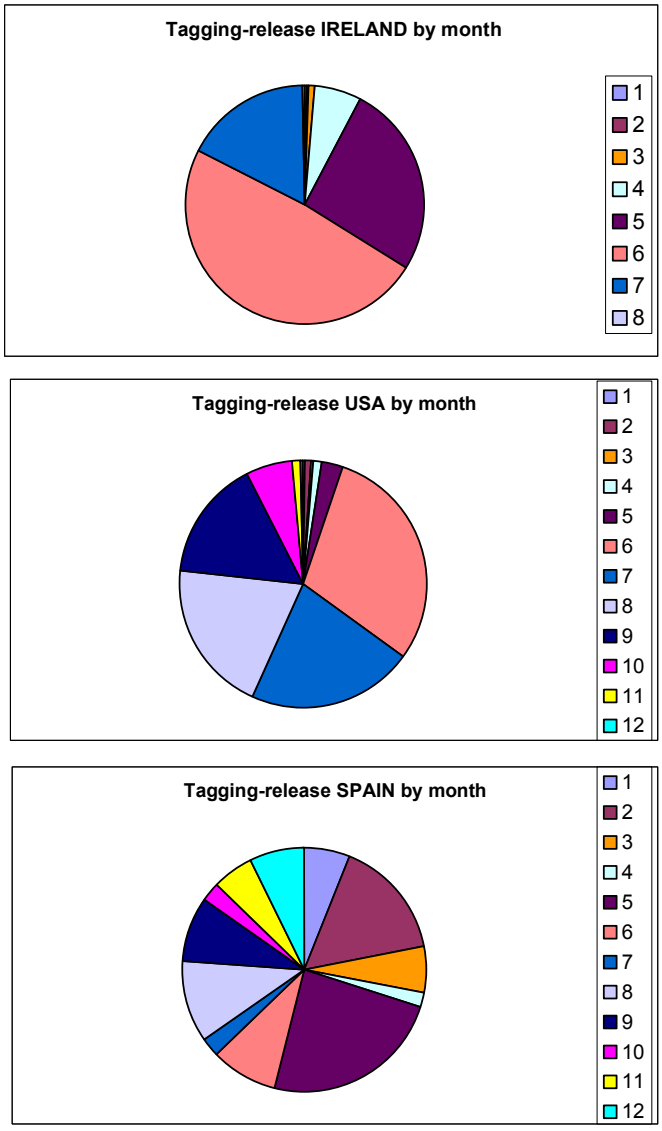


Figure 16. Monthly pattern (%) of releases of pelagic sharks from each tagging program conducted by USA, Ireland and Spain, on the basis of the tags recovered by the Spanish fleet.

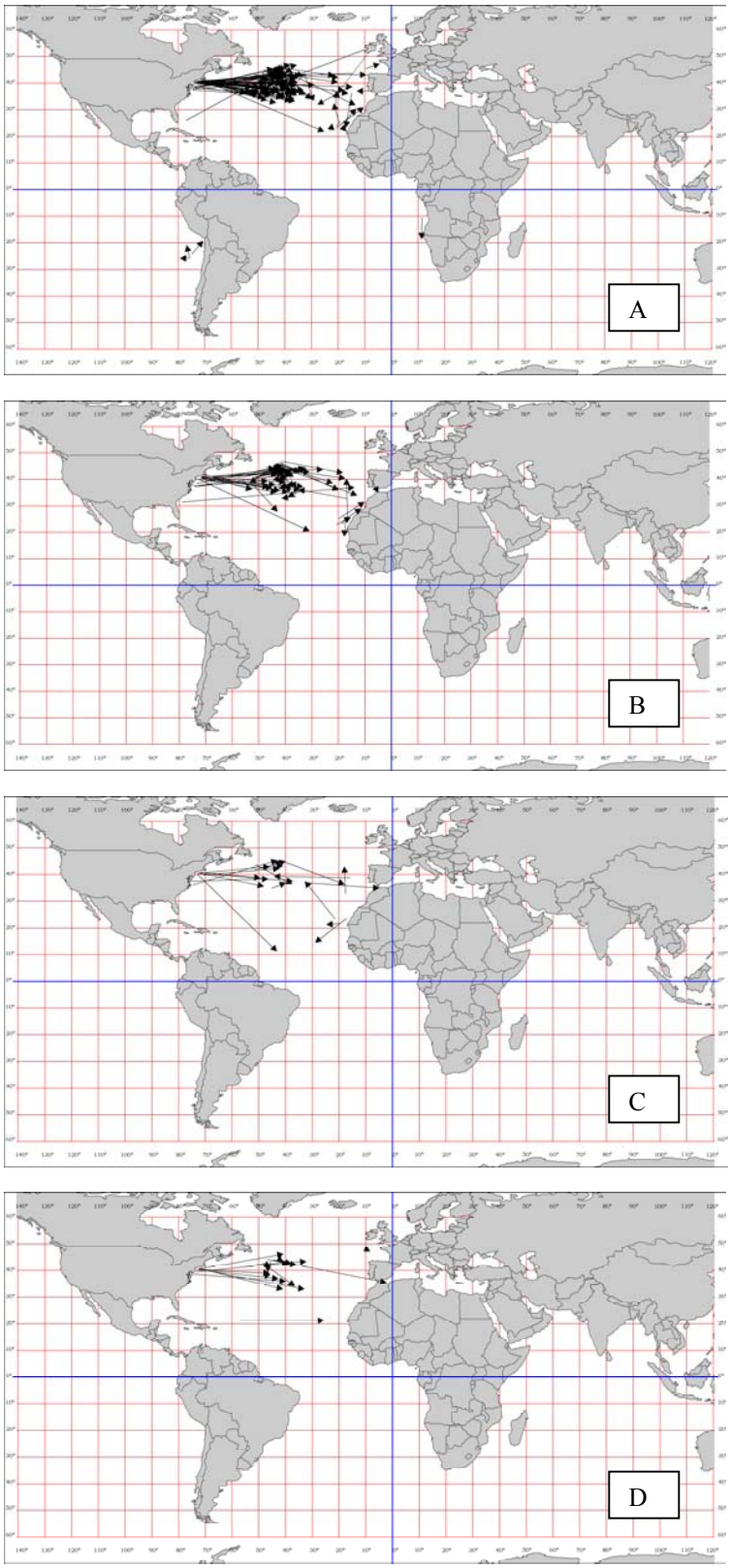


Figure 17. . Rectilinear tagging-recapture movements of *Isurus oxyrinchus* (IOO) individuals. (A) Time at-large: <1 year. (B) 1<= Time at-large <2 years. (C) 2<= Time at-large <3 years. (D) Time at-large >= 3 years.

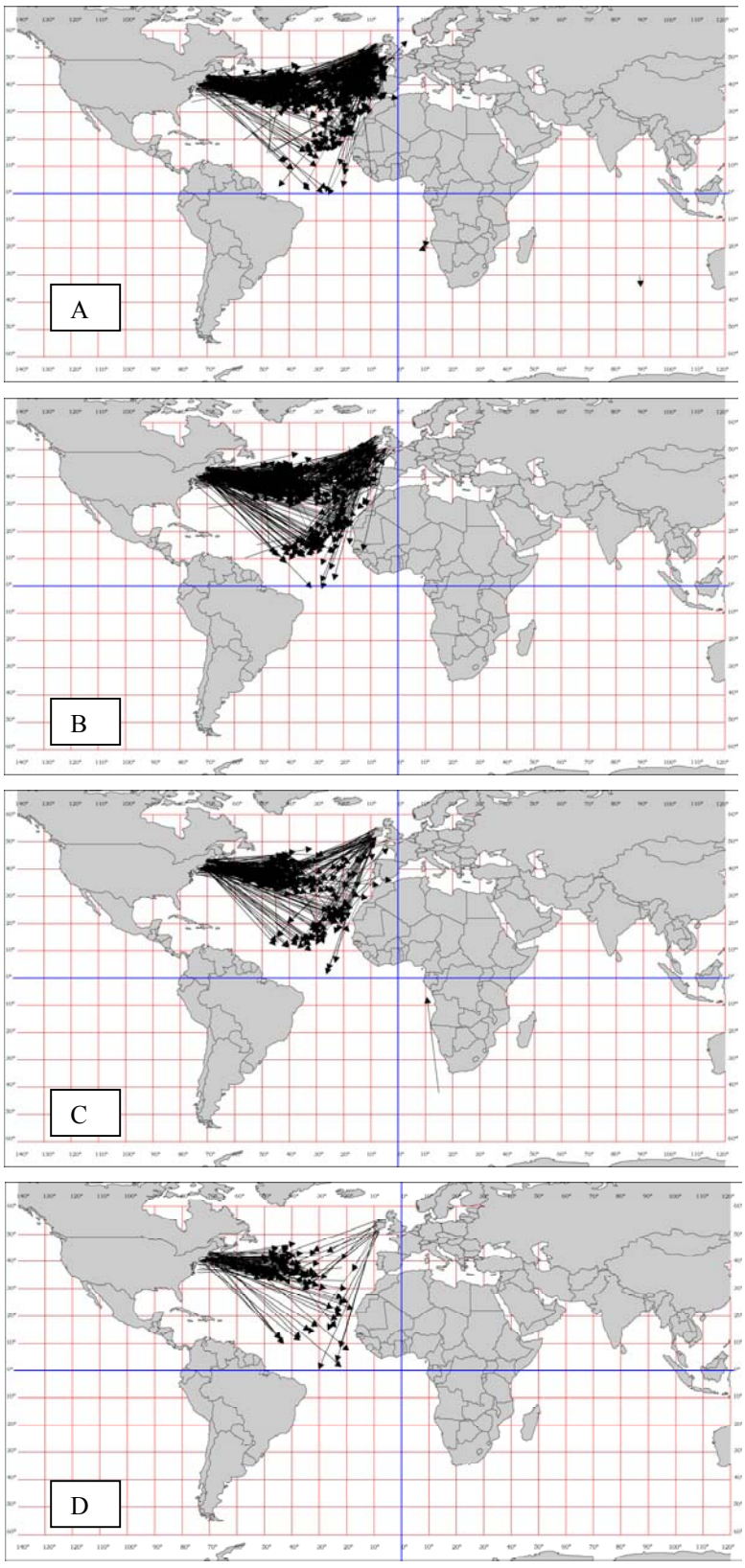


Figure 18. Rectilinear tagging-recapture movements of *Prionace glauca* (PGO) individuals. (A) Time at-large: <1 year. (B) 1<= Time at-large <2 years. (C) 2<= Time at-large <3 years. (D) 3<= Time at-large => 4 years.

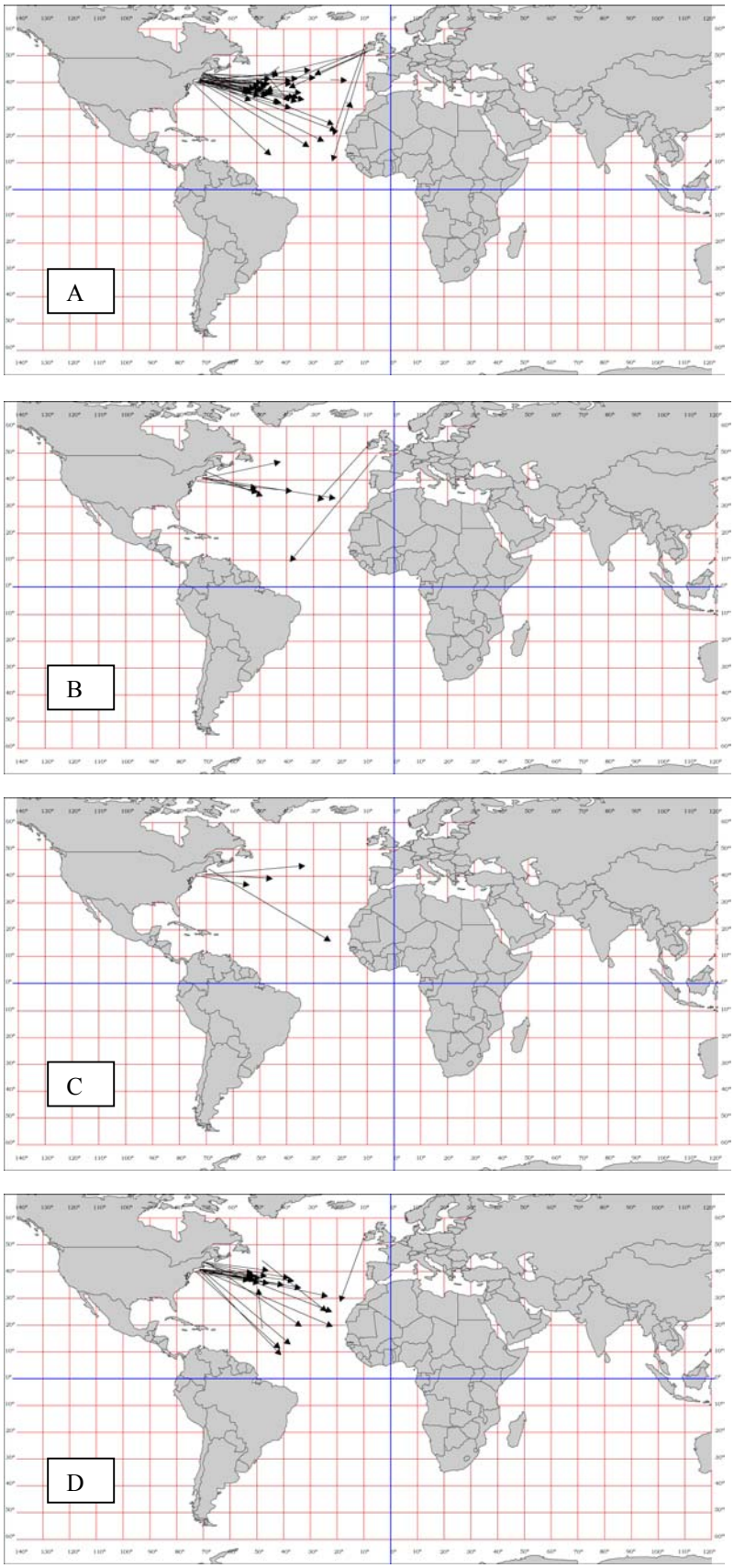


Figure 19. Rectilinear tagging-recapture movements of *Prionace glauca* (PGO) individuals. (A) 4 <=Time at-large < 5 year. (B) 5<= Time at-large <6 years. (C) 6<= Time at-large <7 years. (D) Time at-large => 7 years.

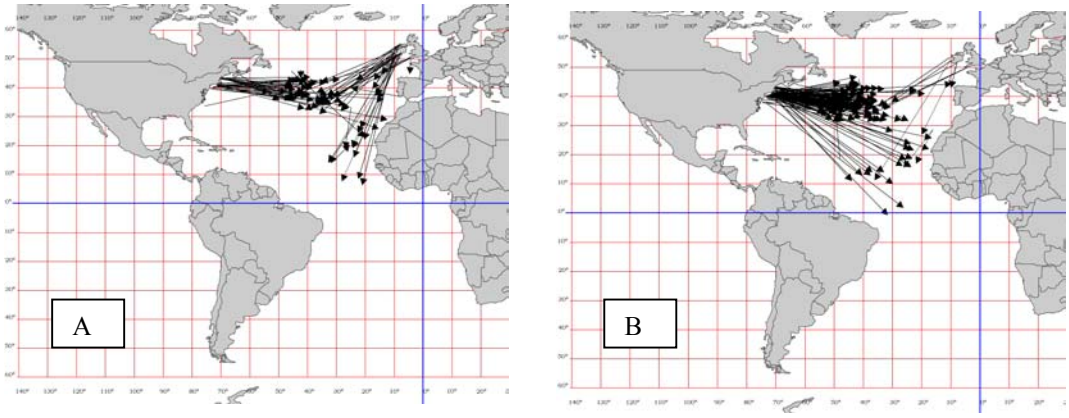


Figure 20. Rectilinear tagging-recapture movements of *Prionace glauca* (PGO) individuals ranging in size from 170-190 cm FL, tagged-released by Ireland and USA, by sex. (A) Females (B) Males.

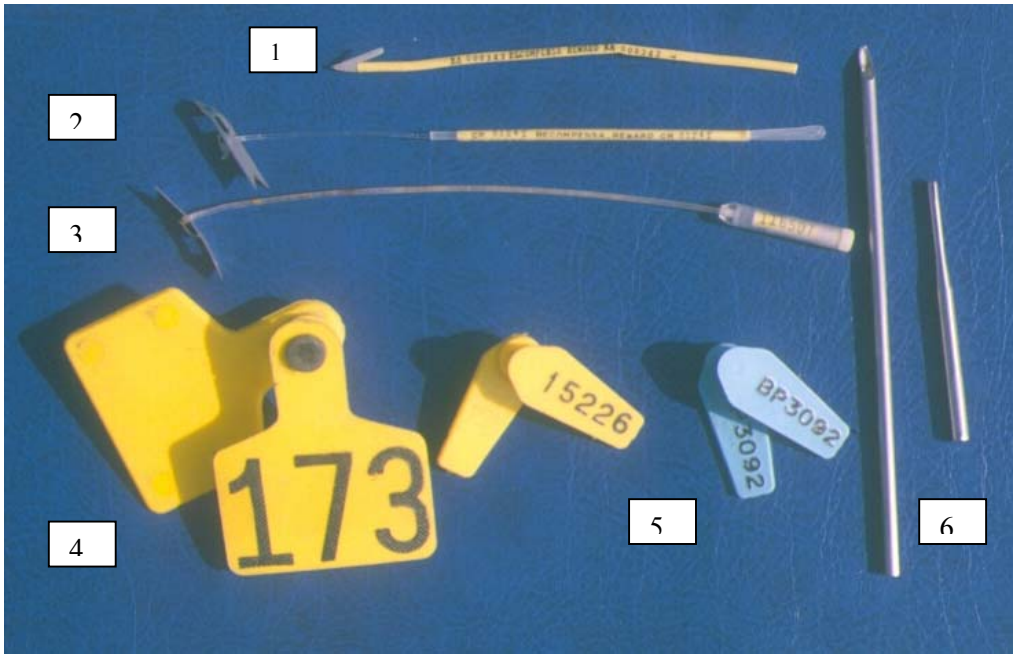


Foto 1. Some different types of tags most commonly recovered by the Spanish surface longline fleet. (1): type D; (2): type H; (3): type M; (4): Super jumbo type; (5): Jumbo type, (6): Applicators.