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Analysis of the Catch Rate of Juvenile Bigeye Depending On the Depth of the Purse-seine Net Used by the Tropical Fleet

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ABSTRACT

This document presents several results obtained in the ABYSS project whose main aim is to study the possible relationship between the catch rate of juvenile bigeye and the depth of the purse-seine net in order to implement the most suitable management measures using the results obtained.

The project was undertaken between June 2008 and April 2010. Temperature and depth loggers were deployed in the nets of 11 tuna purse-seiners operating under the Spanish flag in the Atlantic, Indian and Pacific Oceans.

1648 sets were analyzed, witch provided 61 933 tons of tropical tuna (yellowfin, skipjack and bigeye).

The depth of the nets used ranged from 220 to 309 metres and the fishing depths reached varied between 65 and 226 metres. This means that the percentage of mean depth vis-à-vis net size was 56.73% (range between 20% and 83%). The speed of the falling net varied between 0.1 and 0.2 metres per second.

In addition to the analysis of the catches estimated by the skipper, the study was made using specific composition data of the catch corrected by means of multi-species sampling. On this assumption, the analysis was reduced to 400 sets with 17 230 tons of catch. No differential bathymetric distribution was observed between the 3 species in any of the oceans and in neither of the 2 analyses undertaken (with and without specific correction).

RESUMEN

En este documento se presentan algunos de los resultados obtenidos en el proyecto ***ABYSS*** *cuyo objetivo principal es el estudio de la posible relación entre la captura de patudo juvenil y la profundidad de calado de la red de cerco para poder tomar después, las medidas de gestión más convenientes, acordes con los resultados obtenidos.*

Se desarrolló entre junio de 2008 y abril de 2010. Se utilizaron registradores de temperatura y profundidad que se situaron en las redes de 11 atuneros cerqueros de bandera española que faenaron en los océanos Atlántico, Indico y Pacífico.
Se analizaron 1648 lances que proporcionaron una captura total de 61933 toneladas de túnidos tropicales (rabil, listado y patudo).

Las redes empleadas tenían un calado comprendido entre 220 - 309 metros y las profundidades alcanzadas variaron entre los 65 – 226 metros. Esto supone que el porcentaje medio de calado con respecto al tamaño de la red fue del 56.73% (rango entre 20 – 83 %). La velocidad de caída de la red varió entre 0.1 y 0.2 metros por segundo.

Además del análisis de las capturas estimadas por el patrón se ha hecho el estudio con los datos de composición específica de la captura corregida mediante el muestreo multiespecífico habitual. Con este supuesto el análisis se redujo a 400 lances con 17230 toneladas de captura. No se observó una distribución batimétrica diferenciada entre las tres especies en ninguno de los océanos, en ninguno de los dos análisis realizados (sin corrección y con corrección específica).

Key words: Atlantic Ocean, tropical tuna, purse seine, catches, fishing effort, floating objects, depth net.

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1. Introduction

The four Regional Fisheries Organizations (RFOs) that manage tropical tuna in three oceans: ICCAT (Commission for the Conservation of Atlantic Tunas), IOTC (Indian Ocean Tuna Commission), IATTC (Inter-American Tropical Tuna Commission) and WCPFC (Western and Central Pacific Fisheries Commission) have detected a common problem in purse-seine fishery over artificial objects, involving the incidental catch of juvenile bigeye (*Thunnus obesus*, Lowe 1839). Several Scientific Committees of these RFOs have considered regulatory measures aimed at modifying purse-seine nets under the assumption, not proven, that the greater the depth of the net, the higher the catch of juvenile bigeye.

The ABYSS project was carried out to analyze this assumption. The main aim of this project is to study the possible relationship between the catch rate of juvenile bigeye and the depth of the purse-seine net in order to implement the most suitable management measures according to the results obtained.

During several previous observer campaigns data were collected about the effective depth of the tuna purse-seine nets, but to date no analysis has been made to determine the possible relationship between the increased catch rate of bigeye and the use of deeper nets. The current hypothesis is that the deeper the net, the higher the catch rate of bigeye, based on a possible stratification of the species in the water column under artificial objects.

If the increased catch rate of juvenile bigeye in association with net depth is demonstrated, consideration could be given to modifying fishing gear in order to reduce incidental catches, while attempting to secure the yield of the target species. Conversely, alternative measures would need to be sought.

This project has been undertaken by personnel from the Tropical Tuna Team of the Canary Islands Oceanographic Centre of the Spanish Institute of Oceanography (IEO) on behalf of The Big Frozen Tuna Vessels Producers Association (OPAGAC) and financed by the General Secretariat of the Sea (Ministry of the Environment, Marine and Rural Affairs).

2. Methodology

Although the initial plan included 13 vessels, 11 eventually provided the data: 4 in the Atlantic, 2 in the Indian and 4 in the Pacific Oceans.

2.1. Duration and area of work

The project was implemented in the waters of the Atlantic, Indian and Pacific Oceans, and data was gathered between June 2008 and April 2010.

The working areas in the Atlantic, Indian and Pacific Oceans were located as follows: between 16ºN-13ºS and 13ºE-26ºW; 14ºN-16ºS and 40ºE-80ºE; and 9ºN-12ºS and 137ºE-098ºW, respectively. **Figure 1** shows maps of the approximate area where fishing took place in each ocean.

2.2 Vessel characteristics

Table 1 outlines the main characteristics of the vessels participating in the project: date of entry into service, overall length (in metres), power (in hp) and hold capacity (in cubic metres).

All vessels participating in the project are freezer tuna purse-seiners operating under the Spanish flag and associated with OPAGAC.

2.3 Fishing gear characteristics

Table 2 lists, from lesser to greater depth, details about the purse-seine nets used by the vessels participating in this project: headline, leadline (chain) and depth, all measured in metres.

2.4 Sensor characteristics

Data collection was carried out using 26 autonomous temperature and depth loggers whose specifications were as follows:

Brand: ***NKE***

Model: ***SP2T300*** *(with protection)*

Depth range: Accuracy: Resolution: **9 cm**

Temperature range: **-5°C to +35°C**
Resolution: **11 m°C to 0°C, 13m°C to 10°C, 20 m°C to 20°C**
Accuracy: **0.05°C in the range 0 to +20°C** / **0.1°C** outside this range 1sec response time (90%)

Internal clock with calendar (**+/-1.3 min/month**).
Sampling frequency of 1 sec to 99 h: It is possible to work using 2 different sampling frequencies for temperature profiles.

Memory range: up to 300 000 data (temperature + depth).
Power: permits up to 50 000 000 measurements (temperature + depth), over 3 years of constant operation at 2 sec sampling frequency.

Mechanical characteristics:
Size: **120 mm x 25 mm**.
Weight: **75g** out of water.

Each sensor is enclosed in stainless steel casing for shock protection during manoeuvres.

Data are easily collected electromagnetically from the sensor by means of a data pencil and then downloaded to a computer using the WinMemo programme. The extracted files provide a view of the data recorded during the time the sensor was activated.

In total, 11 data pencils were used (one per vessel).

Figures 2a and **2b** give different views of the depth gauges and protective casing used, showing the knocks received when casting and hauling during the set.

2.5 Sensor installation and data collection

The first stage of the project consisted of installing autonomous loggers (sensors, NKE SP2T300), already used by the IEO in observer campaigns and whose results were considered accurate for gathering the necessary information about temperature and depth. Each vessel was equipped with 2 sensors—of which one was a replacement—with their corresponding steel casing and data pencils.

It was decided that each vessel would install one of the sensors in the net, in the central section of the leadline, which is the part that reaches the maximum depth. Start-up was arranged for early morning, before the first set of the day, and shutdown for the end of the working day. The data were then downloaded to a computer and saved in a duly numbered file.

For this experiment, the sensors were programmed so that the loggers recorded each minute, thereby providing constant information about depth and temperature throughout the entire fishing operation. **Figure 3** shows an example of the log corresponding to one set. Blue indicates the depth graph (in metres) and red that of temperature (in ºC).

2.6 Catch data

For each set, in addition to temperature and depth data, catch data was also recorded per weight category and per species. These data were based on the skipper's estimations, which means that there could be a bias in juvenile catches, as occurs in logbooks.

Each vessel was provided with a form on which the following data was to be noted down for each set:

- Date (D M Y)
- Location (latitude and longitude in degrees and minutes)
- Set number: Numbering will begin at one and will be correlative with the total duration of the project.

- Free school: The box will be marked with a cross if the set is over a free school (not associated with any floating objects).
- Object: The box will be marked with a cross whenever the set is over an object or whale shark.
- Seamount: The box will be marked with a cross whenever the set is over a seamount.
- Current: Data will be taken about the surface current, current direction and strength in knots.

The catches in each set will be noted according to species in the boxes corresponding to yellowfin, skipjack, bigeye and others, along with the estimation of the catch (tons) and the average weight of the specimens (in kilograms).

2.7 Information transfer

At the end of every trip, each vessel was required to transfer the data from the sensor, in addition to the information collected in the forms.

2.8 Data processing

Each vessel sent the data in different formats (dates, currents, weight, etc.), which were then merged into a single format to facilitate subsequent analysis. Classification of the different species according to weight categories was done following the criteria set down in **Table 3**.

Catch data were analyzed depending on the depth of the set. It is evident that, irrespective of the maximum depth of the net, the catch adjudicated to each set corresponds to that made between the depth and the surface.

2.8.1 Correction of the specific composition

Catch data are based on estimations by the skipper, as are the fishing logs. In 1984, the ICCAT Working Group on Juvenile Tropical Tuna (Brest, 1984) established that there was a bias in the logbooks. As a result, from 1980 onwards, a method to correct the specific composition of the catches was used. This method was reviewed in 1991, after the results of a project financed by the EU and undertaken by the IEO and the IRD (Institut de Recherche pour le Développement, France). For this reason, catch data provided by vessels were corrected through sampling on land by sampling teams set up in the main landing ports. This analysis led to a reduction in sample size from 1648 sets with estimations of catch by the skipper to 400 sets with the corrected specific composition.

3. Results

3.1 Depth of net closure

The results obtained were based on the data from 1648 sets of which 471 (29%) were made in the Atlantic, 603 (37%) in the Indian and 574 (35%) in the Pacific Oceans. As for the fishing mode, 380 sets (23%) were made over free schools, 1223 (74%) with floating objects and 45 (3%) over seamounts. Net depth and length varied between 220 m and 309 m (**Table 2**).

Table 4 shows set distribution (in number and percentage) per ocean and fishing mode, as well as the catches obtained in weight and the percentages of each species per fishing mode.

The maximum depth reached by the gear in each set throughout the experiment was registered for each vessel (or net). The maximum depth reached in a set was 226 m and the depths for all the sets varied between 65 m and 226 m. **Figure 4** shows the depths reached in each set for each net.

The depth reached by the net and the percentage it represents vis-à-vis net depth was calculated for each set. The mean percentage of net closure according to net depth was 56.73% and the values ranged from 20% to 83%.

Figure 5 shows the percentages of net closure for each set, according to the depth of purse line closure and the size of the falling net.

3.2 Speed of the falling net

The speed of the falling gear was established per set for each vessel. The falling speeds generally varied between 0.1 and 0.2 m/sec, with higher and lower values found in some vessels. These values reflect the speed reached by the net from start of set to maximum depth.

3.3 Catch composition per species and depth

Two analyses of the data from catch and depth of net closure were made for each set. In the first case, catch data were provided by the skipper of the vessel (estimations of catch per species) and in the second, catch data were corrected against those from the multi-species sampling taken on landing. It is important to note that the number of sets with sampling is considerably lower than the total number of sets made throughout the experiment.

3.3.1 Bathymetric distribution of the catches (specific composition without correction)

Table 4 shows the catches in weight and percentage per species and fishing mode, as well as set distribution (in number and percentage) per ocean and fishing mode. In total, data were obtained from 1648 sets that provided a catch of 61 933 tons. In the case of the Atlantic, 471 sets were made, resulting in 11 471 tons.

Most sets (74.2%) were made over floating objects. Despite being the most practised (53.5%) in the Atlantic Ocean, this fishing mode is proportionally lower compared with the other oceans (77.4%, Indian Ocean, and 87.8%, Pacific Ocean).

Figure 6 gives the catches of all 3 species according to the depth of purse line closure in each set for all 3 oceans. There appears to be no differential bathymetric distribution between the 3 species. The sets with the highest catch, essentially of skipjack, were found at around 150 metres. Bigeye was found at all depth levels.

3.3.2. Bathymetric distribution of the catches (specific composition with correction)

Table 5 shows the catches, with corrected specific composition, in weight and percentage per species and fishing mode, as well as the distribution of sampled sets (in number and percentage) per ocean and fishing mode. In total, data were obtained from 400 sets that provided a catch of 17 230 tons. In the Atlantic, 196 sets were used, resulting in 6870 tons of catch.

It is important to highlight the significant proportion of bigeye observed in catches associated with floating objects in the Pacific Ocean (35.3%), in comparison with the Atlantic and Indian Oceans where much lower percentages were obtained (15% and 12.5%, respectively).

The analysis of the corrected and uncorrected specific compositions pinpoints that skipjack was the dominant species in all catches with floating objects in all 3 oceans.

Figure 7 gives the corrected catches according to the depth of purse line closure in each set for all 3 oceans but with no stratification of the 3 species according to depth. In the Atlantic Ocean, bigeye catches were made in sets between 60 m and 200 m, while the sets with greater catches, only of skipjack and yellowfin, were made at depths ranging from 150 m to 200 m.

4. Conclusions

- The depth and length of the gear varied between 220 m and 309 m, while depth closure ranged from 65 m to 226 m.

- The mean percentage of depth, according to net size, was 56.73% (ranging from 20% to 83%).

- The speed of the falling net generally varied between 0.1 and 0.2 m/sec.

- Skipjack was the dominant species in all 3 oceans in the floating objects mode. In the Pacific, yields were obtained between 50 m and 200 m and in the Indian and Atlantic, between 50 m and 250 m.

- No differential bathymetric distribution was observed between the 3 species in any of the oceans.

- It would be advisable to extend the study to include additional analyses, for example, by detailed analysis of the catches obtained in the more shallow interval (for example, depth up to 120m) and/or by stratifying the catches according to time of catch.

ACKNOWLEDGEMENTS

We would like to thank the IATTC (Inter-American Tropical Tuna Commission) for supplying information about multi-specific sampling (composition per species and size) undertaken on Spanish vessels participating in this experiment.

BIBLIOGRAPHY

DELGADO DE MOLINA, A., J.C. Santana, J. Ariz, P. Pallarés, 2004. Profundidad del arte de cerco en la pesquería atunera tropical. Col. Doc. Cient. CICAA, 56(2): 780-783.

ICCAT. 2009. Manual de ICCAT. Comisión internacional para la conservación del atún Atlántico. ICCAT, ISBN (Edición electrónica): 978-92-990055-2-1.

SANTANA, J.C., A. Delgado de Molina, J. Ariz, P. Pallarés y Daniel Gaertner, 2002. Algunos datos sobre la profundidad que alcanza el arte de cerco en la pesquería atunera tropical. Col. Doc. Cient. CICAA, 54: 157-171.

Table 1. Main characteristics of the vessels participating in the project.

	NOMBRE DEL BUQUE	FECHA DE ENTRADA EN SERVICIO	ESLORA TOTAL (metros)	POTENCIA (c.v)	CAPACIDAD m³
OCÉANO PACÍFICO	ROSITA C	30/10/2000	84,1	4076	2060
	AURORA B	19/05/1998	84,1	4080	2060
	ALBACORA UNO	01/01/1996	105	6004	2650
	ALBATÚN TRES	30/09/2004	115	6696	3095
OCÉANO ÍNDICO	ALBATÚN DOS	30/04/2004	116	7795	3250
	ALBACÁN	04/09/1991	85,85	4023	1900
	ALBACORA CUATRO	16/02/1974	83,45	4000	1850
OCÉANO ATLÁNTICO	KURTZIO	19/02/1976	56,1	2200	750
	MAR DE SERGIO	26/06/1984	84,2	5704	1850
	ALMADRABA DOS	26/11/1979	66	4800	1350
	MATXIKORTA	19/01/1976	56,1	2200	850
	ALMADRABA UNO	13/03/1977	52,25	3000	925
	ALBACORA QUINCE	04/05/1983	85,85	4580	1850

Table 2. Fishing gear characteristics of each vessel (relinga de corchos = headline; relinga de plomos = leadline; calado = depth)
.

Relinga de corchos (m)	Relinga de plomos (m)	Calado (m)
1450	1700	220
1720	2000	220
1600	1800	230
1590	1900	240
1387	1650	245
1300	1600	255
1.600	1800	260
1750	1900	270
1598	-----	280
1600	-----	280
1671	-----	285
1699	1971	289
1799	-----	309

Table 3. Category codes according to the weight of bigeye, skipjack and yellowfin caught.

Rabil / patudo		listado	
peso	código	peso	código
-3	1	- 1,8	1
3 - 10	2	+ 1,8	2
11 - 30	3	1,8 - 4	3
3 - 30	4	1,8 - 6	4
31 - 50	5	4 - 6	5
11 - 50	6	4 - 8	6
+ 50	7	6 - 8	7
+ 10	8	+ 8	8

Table 4. Sets (number and percentage) per ocean and fishing mode catch weight (uncorrected specific composition) and percentages of each species per fishing mode.

	PACIFIC OCEAN				INDIAN OCEAN				ATLANTIC OCEAN				3 OCEAN			
	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL
YFT	173	5481	0	5654	1918	3078	1119	6115	4481	1400	0	5881	6572	9959	1119	17650
SKJ	1642	20686	0	22328	157	9133	497	9787	297	4645	0	4942	2096	34464	497	37057
BET	15	5469	0	5484	213	729	152	1094	105	543	0	648	333	6741	152	7226
Total tons	1830	31636	0	33466	2288	12940	1768	16996	4883	6588	0	11471	9001	51164	1768	61933
Total sets	70	504	0	574	91	467	45	603	219	252	0	471	380	1223	45	1648

	PACIFIC OCEAN				INDIAN OCEAN				ATLANTIC OCEAN				3 OCEAN		
	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount
% YFT	9,5	17,3	0,0	16,9	83,8	23,8	63,3	36,0	91,8	21,3	0,0	51,3	73,0	19,5	63,3
%SKJ	89,7	65,4	0,0	66,7	6,9	70,6	28,1	57,6	6,1	70,5	0,0	43,1	23,3	67,4	28,1
%BET	0,8	17,3	0,0	16,4	9,3	5,6	8,6	6,4	2,2	8,2	0,0	5,6	3,7	13,2	8,6
% catch by type	5,5	94,5	0,0	100	13,5	76,1	10,4	100	42,6	57,4	0,0	100			
% total sets	12,2	87,8	0	100	15,1	77,4	7,5	100	46,5	53,5	0	100	23,1	74,2	2,7

Table 5. Sets (number and percentage) per ocean and fishing mode catch weight (corrected specific composition) and percentages of each species per fishing mode.

	PACIFIC OCEAN				INDIAN OCEAN				ATLANTIC OCEAN				3 OCEAN			
	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL
YFT	0	194	0	194	584	1606	219	2409	1277	1727	0	3003	1861	3526	219	5606
SKJ	0	1398	0	1398	41	4174	325	4541	46	2939	0	2985	87	8511	325	8924
BET	0	869	0	869	37	829	82	949	60	822	0	883	97	2521	82	2701
Total tons	0	2461	0	2461	663	6610	626	7899	1382	5488	0	6870	2045	14559	626	17230
Total sets	0	36	0	36	11	146	11	168	32	164	0	196	43	346	11	400

	PACIFIC OCEAN				INDIAN OCEAN				ATLANTIC OCEAN				3 OCEAN		
	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount	TOTAL	F.S	Obj	Sea mount
% YFT	0,0	7,9	0,0	7,9	88,1	24,3	35,0	30,5	92,4	31,5	0,0	43,7	91,0	24,2	35,0
%SKJ	0,0	56,8	0,0	56,8	6,3	63,2	51,9	57,5	3,3	53,6	0,0	43,4	4,3	58,5	51,9
%BET	0,0	35,3	0,0	35,3	5,6	12,5	13,1	12,0	4,4	15,0	0,0	12,8	4,8	17,3	13,1
% catch by type	0	100	0	100	8	84	8	100	20	80	0	100			
% total sets	0	100	0	100	6,5	86,9	6,5	100	16,3	83,7	0	100	10,8	86,5	2,8

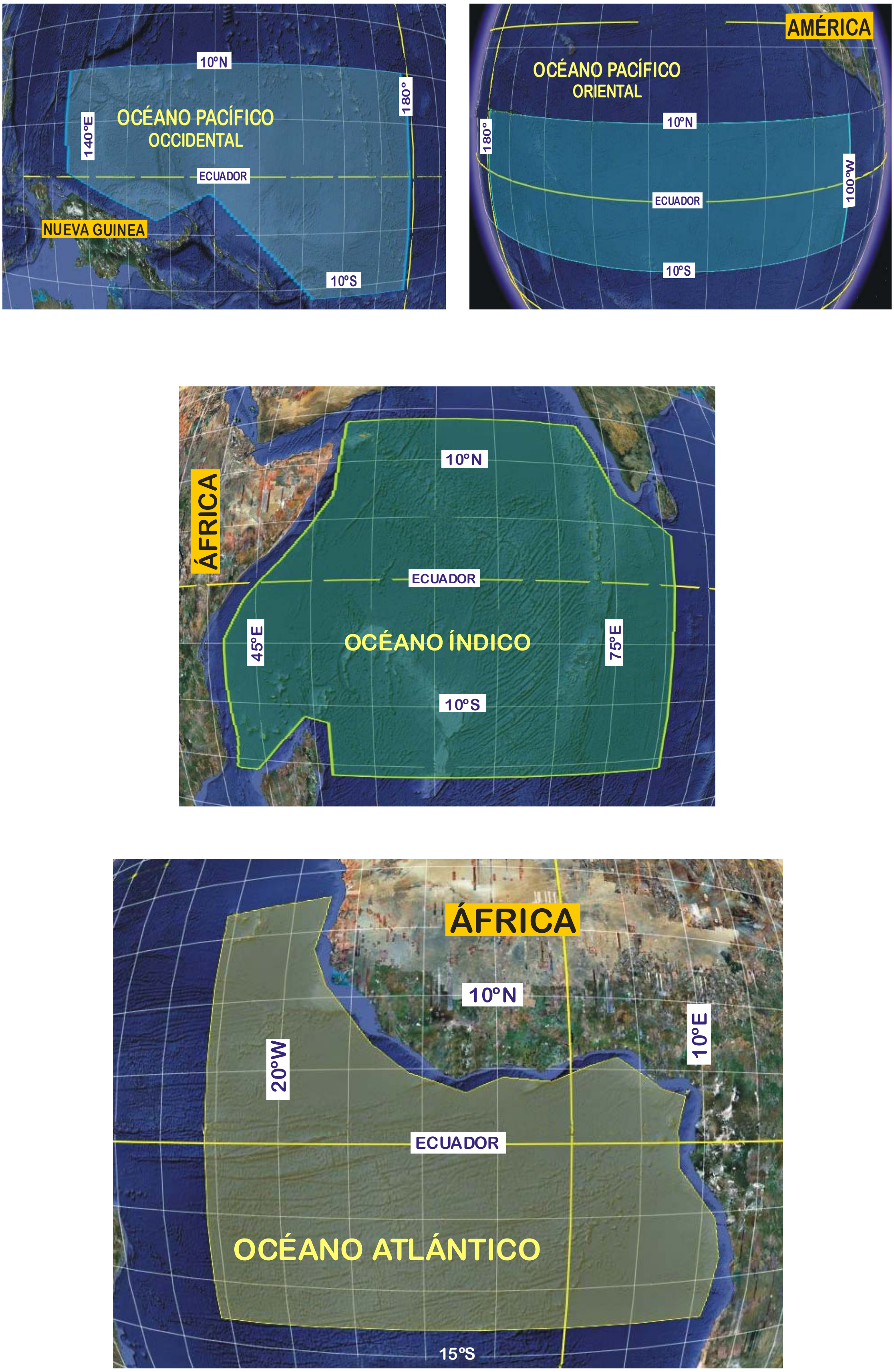

Figure 1. Working area.

Figure 2a. Different views of one sensor.

Figure 2b. Protective casing of a sensor.

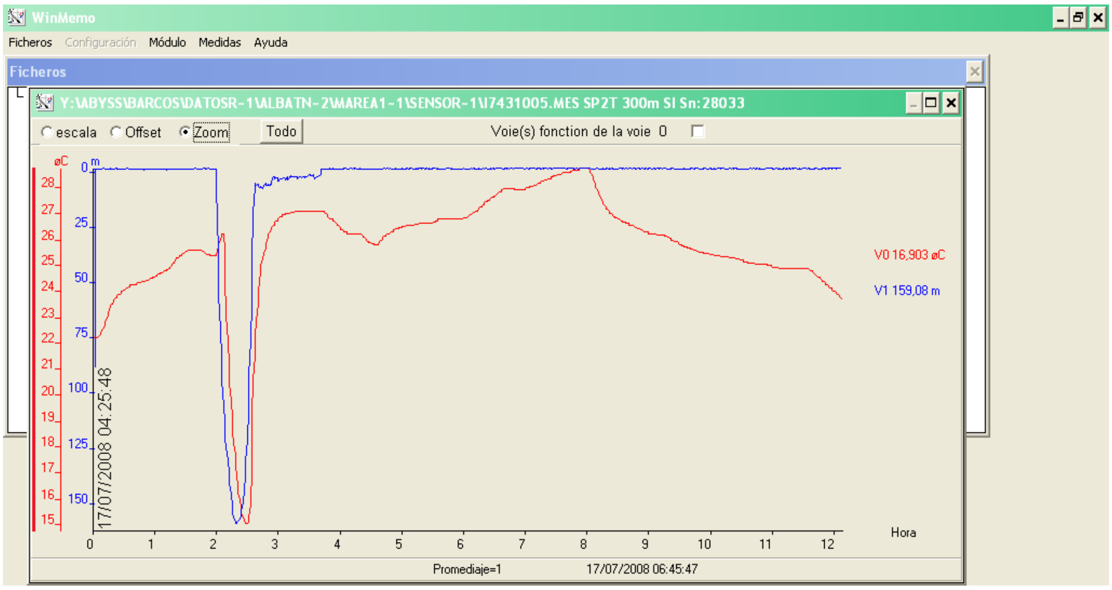

Figure 3. Sensor log of a set.

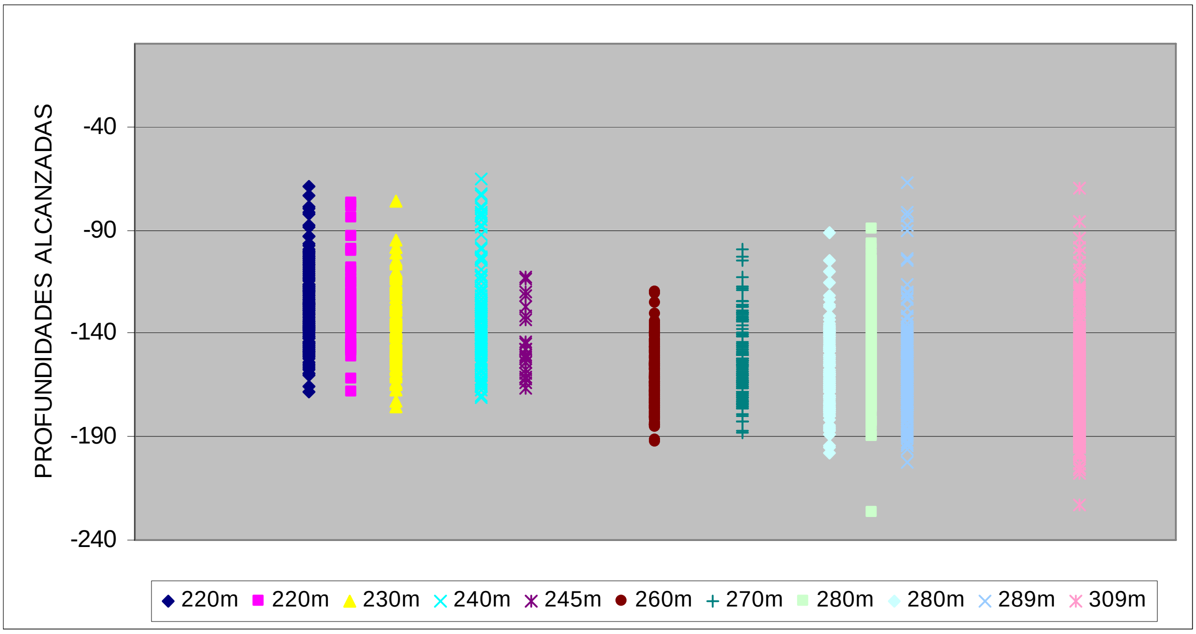

Figure 4. Depth reached by each net in each set. The axis of abscissas shows the depth of each net in metres.

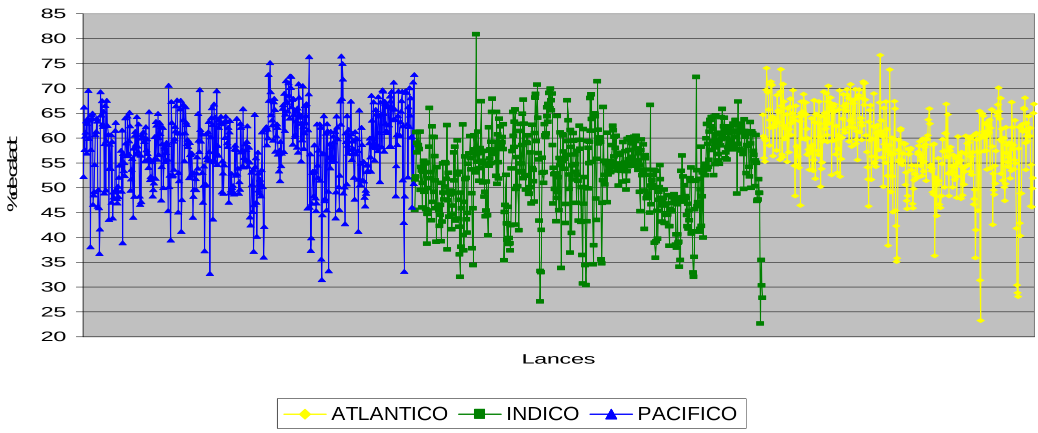

Figure 5. Percentage of the depth of the net in each set. The colours show the sets made in each ocean.

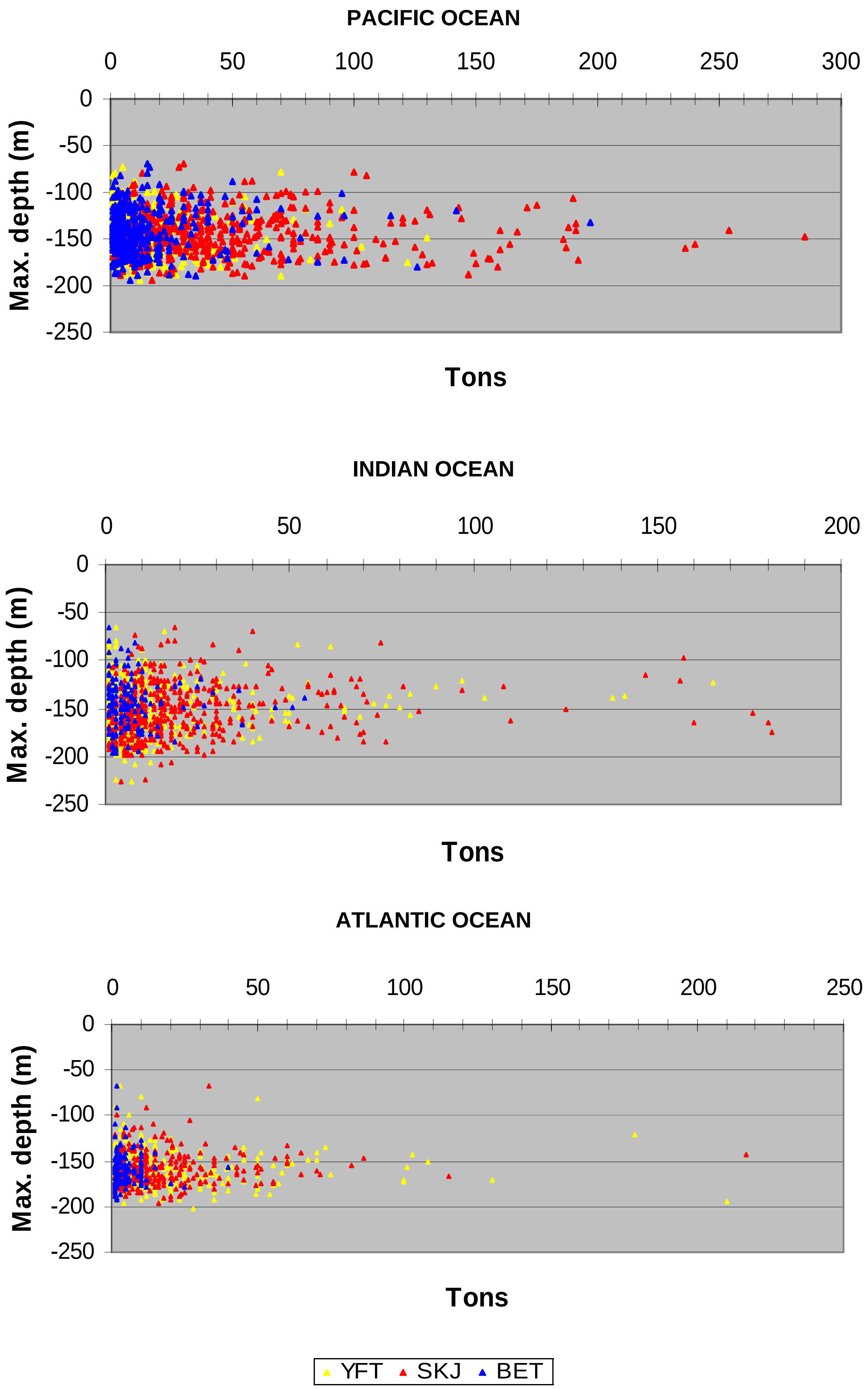

Figure 6. Catches (no specific correction) per species according to depth of purse line closure in each set for all 3 oceans.

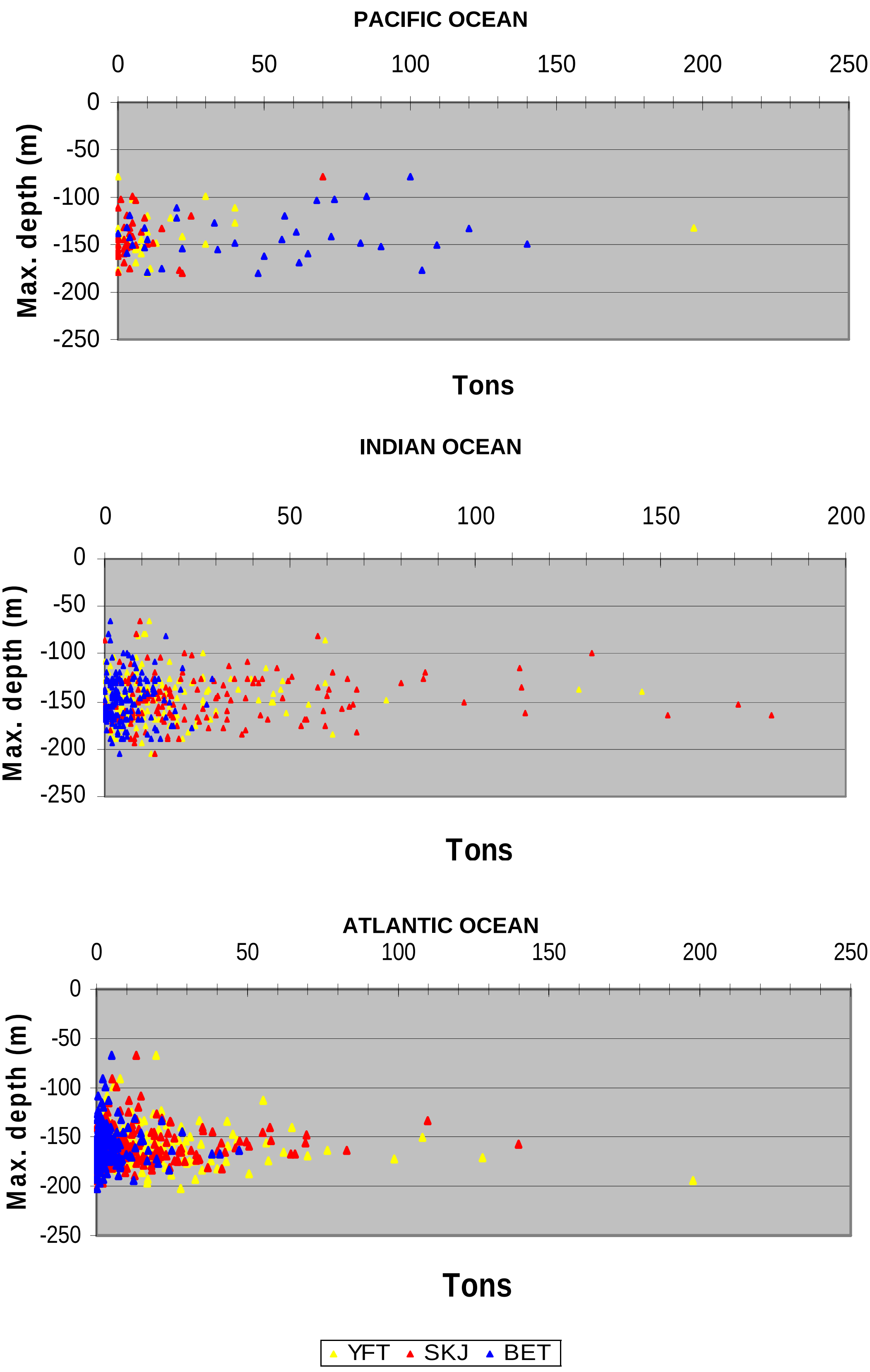

Figure 7. Catches (with specific correction) per species according to depth of purse line closure in each set for all 3 oceans.