SWIOFP Project

Component 4 - Survey of pelagic fishes in the South West Indian Ocean

Composante 4 – Prospections des poissons pélagiques du Sud-Ouest de l'Océan Indien

Report of the instrumented longline fishing experiments training course carried out on board the F/V "Brahma" from 23rd February to 3rd March 2011

Rapport de la formation à la réalisation de pêches une palangre instrumentée effectuée à bord du palangrier « Brahma » du 23 février au 3 Mars 2011

BACH P.

La Réunion – March 2013

CONTENTS

Citation :

Bach P., 2013. SWIOFP Project: Report of the instrumented longline fishing experiments training course carried out on board the fishing vessel "Brahma" from 23rd of February to 3rd of March 2011. IRD/SWIOFP Report, 32 pp.

Context : SWIOFP/ASCLME project

Up to now, only tuna and some large pelagic fishes associated with tuna fisheries in the South Western Indian Ocean are under monitoring and management by the regional fisheries management organization (RFMO): Indian Ocean Tuna Commission (IOTC). However many other marine living resources in the region are exploited by commercial fisheries and require a regional approach in order to improve their respective management in an "ecosystem approach to fisheries" perspective. These resources are mostly spread along Exclusive Economic Zones (EEZs) of coastal countries representing shared stocks of crustaceans, demersal fishes and small pelagic fishes. Because of the weakness of financial supports in marine fisheries research in the region compared to the diversity of stocks to manage, both scientists and policy managers have to share information and knowledge to improve marine resource management at local, regional and basin-wide scales. Moreover, the south-western part of the Indian Ocean is known to be home of several endangered species of the marine megafauna (sea turtles, marine mammals) and the improvement of biological knowledge regarding these species is essential in order to reduce interactions with fishing activities. The South West Indian Ocean Fishery Commission became operational relatively recently. The aim of this Commission is to promote a regional management of local fisheries complementary to marine fisheries management activities of the Indian Ocean Tuna Commission. This management will be structured around the three core functions of fisheries management: monitoring/survey, control (decisions on the appropriate exploitation levels) and surveillance (strict monitoring of compliance). Activities regarding the survey/monitoring are classically carried out by the Scientific and Technical Committee (SCT) Major objectives for the first five years of the SWIOF Project are to develop operational framework to implement an efficient MCS. This initiative does not necessarily depend on the emergence of the SWIOFC but it represents a driver of its survey/monitoring function.

Indeed, the principal components are:

☞ Integration of local fishery database at a regional level,

☞ Audit of knowledge in general (scientific, technical) of major exploited stocks (crustaceans, demersal stocks and small and large pelagic fishes) with the aim of respective estimations of exploitation levels,

☞ The collect of data for non-commercial species due to theirs interactions with commercial fisheries (for instance some marine mammals interacted with gillnet fisheries, sea turtles interacted with longline fishery and purse seine fishery on FAD).

Countries involved in the project are countries of the South West Indian Ocean having coast along the ocean : Kenya, Tanzania, Mozambique, Republic of South Africa, Seychelles, Comoros, Madagascar, Mauritius and France (Eparses Islands, Mayotte, Tromelin, Reunion). Somalia could be soon integrated in the project as observer country.

The global cost of these five years project is 21 millions $ US (~ 16 millions €).

The French Fund for the Environment (FFEM = Fonds Français pour l'Environnement Mondial) participates in this project as co-financial support at a level of 800 K€ (1 millions of US $). Essentially, these funds are mobilized to support 3 components of the project :

- Component 1 "Data and Information": Gap analysis and supply of an integrator database software named « StatBase »,
- Component 4 "Pelagic Fishes": Electronic tagging programme for swordfish and bigeye tuna, deployment of anchored Fish Aggregating Devices (FADs) allowing managing actions to increase the number of fishing activities for a given fishing pressure, improvement of fishing gear (develop methods to mitigate adverse impact of some fishing practices, application of the ecosystem based approach to fisheries),
- Component 5 "Non-commercial species": research studies of some marine mammals populations interacting with longline fisheries in the region, research programme of sea turtles movement behaviour to identify area and period for which the risk of accidental mortality due to fishing activities is high.

This project is carried out at a regional scale simultaneously with the ASCLME project (Agulhas Somalia Current Large Marine Ecosystem). One of the objectives of the ASCLME project is to develop indicators (simple or composite) to characterize ecosystems. As corollary of this objective, ASCLME investigates physical and biological characteristics of the ocean in this region and then the habitat of marine living resources targeted in the SWIOF project. These two regional projects ASCLME and SWIOFP are parts of a set of project included in the Marge Marine Ecosystem international project. These two projects share some tools or operational framework such as oceanographic cruises.

1 Introduction: SWIOFP Instrumented Longline training cruise

Pelagic fish surveys with an instrumented longline (ILL) were proved as a relevant way to collect valuable information to improve our knowledge of interactions between the pelagic resource and the fishing gear (Bach et al., 2003[1]):

- ✓ the behaviour of the fishing gear while fishing to measure the volume of the habitat prospected according to the tactic of the mainline setting,

1 - Bach P., L. Dagorn, A. Bertrand, E. Josse, C. Misselis, 2003. Acoustic telemetry versus monitored longline fishing for studying the vertical distribution of pelagic fish : bigeye tuna (*Thunnus obesus*) in French Polynesia. Fish. Res., 60 (2-3), 281-292.

- ✓ the habitat of species inferred from the position of the hook on the basket mainline, the hooking time, the shape of the mainline when the capture occurred and the environment (temperature, oxygen, …) characterizing the fishing station,
- ✓ the hooking pattern of both target species and bycatch along the fishing time,

So far, two cruises to prospect large pelagic fishes in the SWIO in general and the Mozambique Channel in particular have been carried out (Bach et al., 2009 [2]; Bach et al., 2013 [3]). During a SWIOFP meeting held in Seychelles in 2010, national coordinators for the component 4 solicited France to organize 1 or 2 training cruises to allow each partner of the SWIO region for being able to carry out instrumented longline surveys by themselves.

The commercial longliner, the F/V « Brahma » based in La Reunion was wet-leased to achieve this instrumented longline (ILL) training.

Six fishery technicians and students from the SWIO region participated in:

- ❖ FAHARDINE Ahamada (Fishery Administration of Comores),
- ❖ BEHIVOKE Faustinato (IHSM Madagascar),
- ❖ MUHAJI Chande (TAFIRI, Tanzanie),
- ❖ NDEGWA Stephen (KMFRI, Kenya),
- ❖ CUNEE Moganah Nadeen (Ministry of fisheries Mauritius)
- ❖ JULIE Danny (Seychelles Fishing Authority) our colleague and friend left us suddenly and unexpectedly in April 2012. May his soul rest in peace.

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2 - Bach P., E. Romanov, T. Filippi, 2009. SWIOFP/ASCLME Project: Mesoscale eddies and large pelagic fish in the Mozambique Channel – Report of monitored longline fishing experiments carried out on board the fishing vessel "Manohal" from 27th of November to 18th of December 2008. IRD/SWIOFP Report, 74 p.

3 - Bach P., T. Fillipi, G. Berke & A. Sharp, 2013. SWIOFP/ASCLME Project: Mesoscale eddies and large pelagic fish in the Mozambique Channel – Report of monitored longline fishing experiments carried out on board the fishing vessel "Brahma" from 1st to 20 of April 2010. IRD/SWIOFP Report, 33 pp.

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SWIOFP participants to the ILL training cruise

The objectives of this ILL training were :

1. To familiarize trainees with the necessary material to fish with a monofilament pelagic longline (spool, mainline, branchline, hooks, floats, radio buoys, goniometer, beeper). The shooter necessary to give a slack to the mainline in order to set the mainline deeper in order to target tunas was not installed on the longliner,
2. To deploy the longline and its instrumentation (hook timer – HT, time depth recorder – TDR) according to a given fishing tactic (for example attachment point of the TDR to measure the maximum fishing depth),
3. To collect data characterizing the fishing operation (setting, hauling),
4. To collect biometric (length) and biological (sex, sexual maturity, muscle sampling for genetic and isotope analysis),
5. To familiarize trainees with the principal large pelagic fishes in longline catches,
6. To fill the different sampling forms aimed at collected all the information on the fishing operation, the spatio-temporal positions of catches along the longline (hook timer data,

hook number on the basket, basket number on the longline), the status of the fish at hauling, the position of the hook on the fish caught, biometric and biological individual fish data,

7. To use the Win Memo (NKE) software to configure time depth recorders before deployment, to download the data recorded and save them in a ASCII format for further analysis,
8. To deploy XBT (expendable bathythermograph) to obtain temperature – depth profile associated to the fishing station or to characterize the oceanographic environment at a larger scale.

In the middle of the training course at sea one morning was dedicated to briefly present:

1. the interest of the measure of the hooking time obtained from hook timers associated to fishing depth records (TDR data) to describe the habitat of large pelagic fishes,
2. the COPAL software [4].

4 - Bach P., Romanov E. & D. Gaertner, 2012— COPAL (COmportement de la PALangre). Longline behaviour modelling software. Version 2.7. IRD.

2 Time schedule of operations

This training cruise of the SWIOFP Component 4 « Pelagic Fishes » started on Wednesday 23rd of February 2011 from Le Port (La Reunion) at 12:00 pm.
The route of the cruise (date, time, latitude, longitude every 5 minutes) will be obtained from the vessel monitoring system (VMS) and these data were stored in the SEALOR [5] database.

The synthetic representation of operations at sea (hydrology, instrumented longline fishing) is displayed on the Figure 1. Date, time and positions of instrumented longline sets and XBT stations are resumed in the Table 1A and Table 1B, respectively. Instrumented longline fishing sets and XBT stations are displayed on the figure 2.

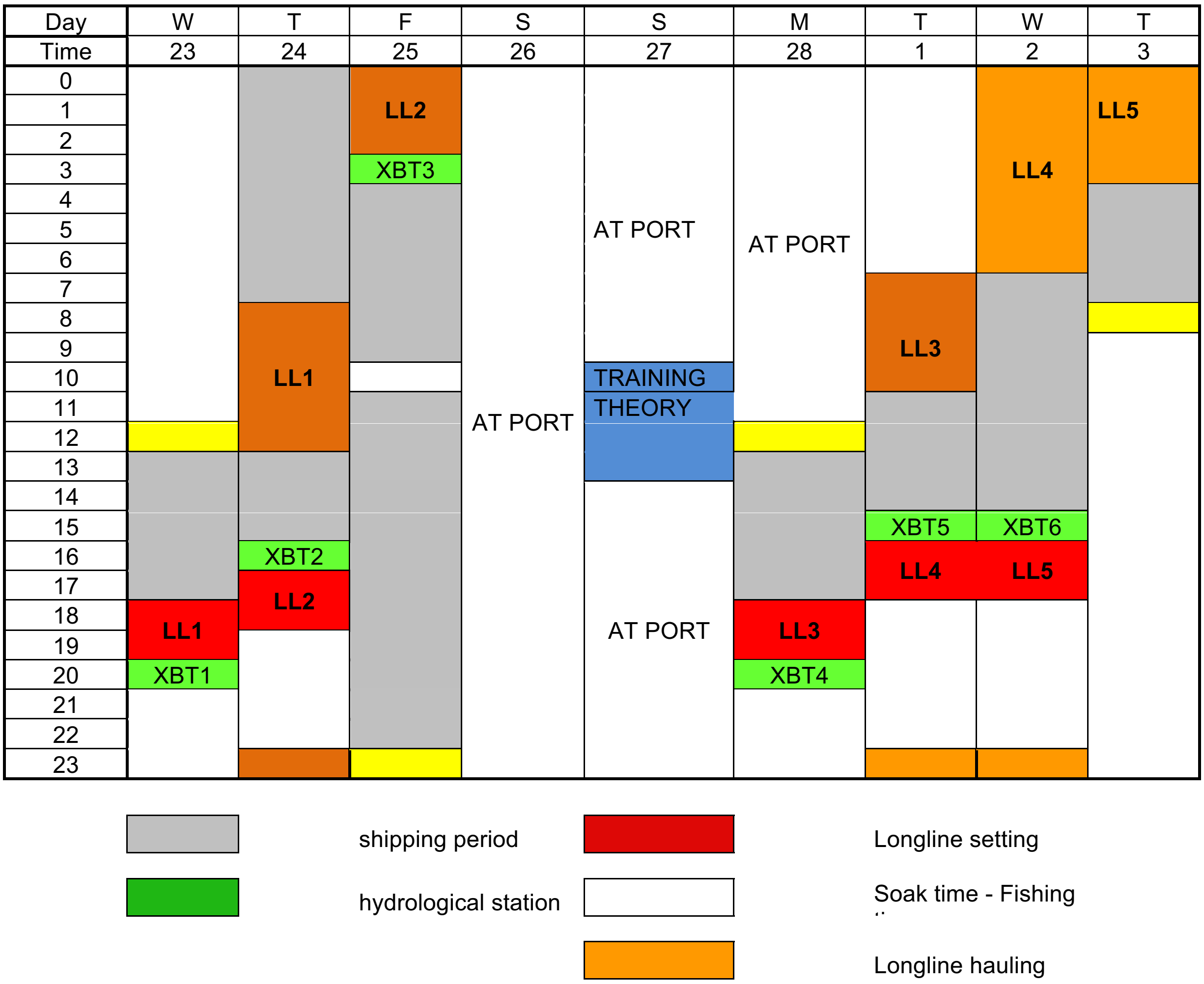


Figure 1 – Chronogram of operations carried out on board the F/V "Brahma" during the SWIOFP Instrumented Longline (ILL) training cruise.

5 - Bach P., N. Rabearisoa, T. Filippi & S. Hubas, 2008 - The first year of **SEALOR** : Database of **SEA**-going observer surveys monitoring the local pelagic **LO**ngline fishery based in La **R**eunion. IOTC/WPEB/WP13, 26 p

Table 1 A – Time, date and positions of instrumented longline sets.

			START		
Date	Set N°	Operation	Local time	Lat (°S)	Long (°E)
23/02/11	1	Setting	04:00	10.506	40.506
24/02/11	1	Hauling	11:00	-10.506	-40.506
24/02/11	2	Setting	03:00	-20.647	55.025
25/02/11	2	Hauling	11:00	-20.595	55.009
05/12/08	3	Setting	03:50	-20.473	54.412
28/02/11	3	Hauling	12:00	-20.442	54.37
01/03/11	4	Setting	04:10	-21.064	54.765
01/03/11	4	Hauling	11:55	-20.976	54.782
02/03/11	5	Setting	04:29	-21.182	54.246
02/03/11	5	Hauling	12:00	-21.143	54.261

			END		
Date	Set N°	Operation	Local time	Lat (°S)	Long (°E)
23/02/11	1	Setting	06:55	20.506	50.339
24/02/11	1	Hauling	15:40	-20.506	-50.339
24/02/11	2	Setting	05:20	-20.567	54.867
25/02/11	2	Hauling	15:20	-20.504	54.852
05/12/08	3	Setting	06:05	-20.476	54.21
28/02/11	3	Hauling	16:23	-20.451	54.205
01/03/11	4	Setting	06:25	-21.065	54.544
01/03/11	4	Hauling	17:35	-20.965	54.603
02/03/11	5	Setting	06:39	-21.008	54.14
02/03/11	5	Hauling	17:00	-20.973	54.158

Date	Set N°	Operation	Bearing (°)	Distance (km)
23/02/11	1	Setting	42	1532.36
24/02/11	1	Hauling	222	1532.36
24/02/11	2	Setting	298	18.72
25/02/11	2	Hauling	302	19.25
05/12/08	3	Setting	269	21.07
28/02/11	3	Hauling	267	17.24
01/03/11	4	Setting	270	22.96
01/03/11	4	Hauling	274	18.65
02/03/11	5	Setting	330	22.28
02/03/11	5	Hauling	330	21.74

The F/V "Brahma" departed from Le Port, La Reunion on Feb. 23 and was back at the same location on Feb. 25 for the first leg and started on Feb. 28 and was back on March 3 for the second leg. The fishing sets were carried out close to west coast of the La Reunion Island in order to optimize the time at sea. Five longline sets were operated (Figure 2).

Table 1 B – Time, date and positions of XBT casts.

XBT N°	Date	Local time	Lat (°)	Long (°)	N°XBT
XBB1	23/02/11	20:40	-20.567	54.867	329547
XBT2	24/02/11	16:10	-20.475	54.42	329551
XBT3	25/02/11	02:40	-20.445	54.201	329552
XBT4	28/02/11	20:40	-21.067	54.5	329553
XBT5	01/03/11	16:20	-21.188	54.25	329554
XBT6	02/03/11	13:30	-21.062	54.147	329555

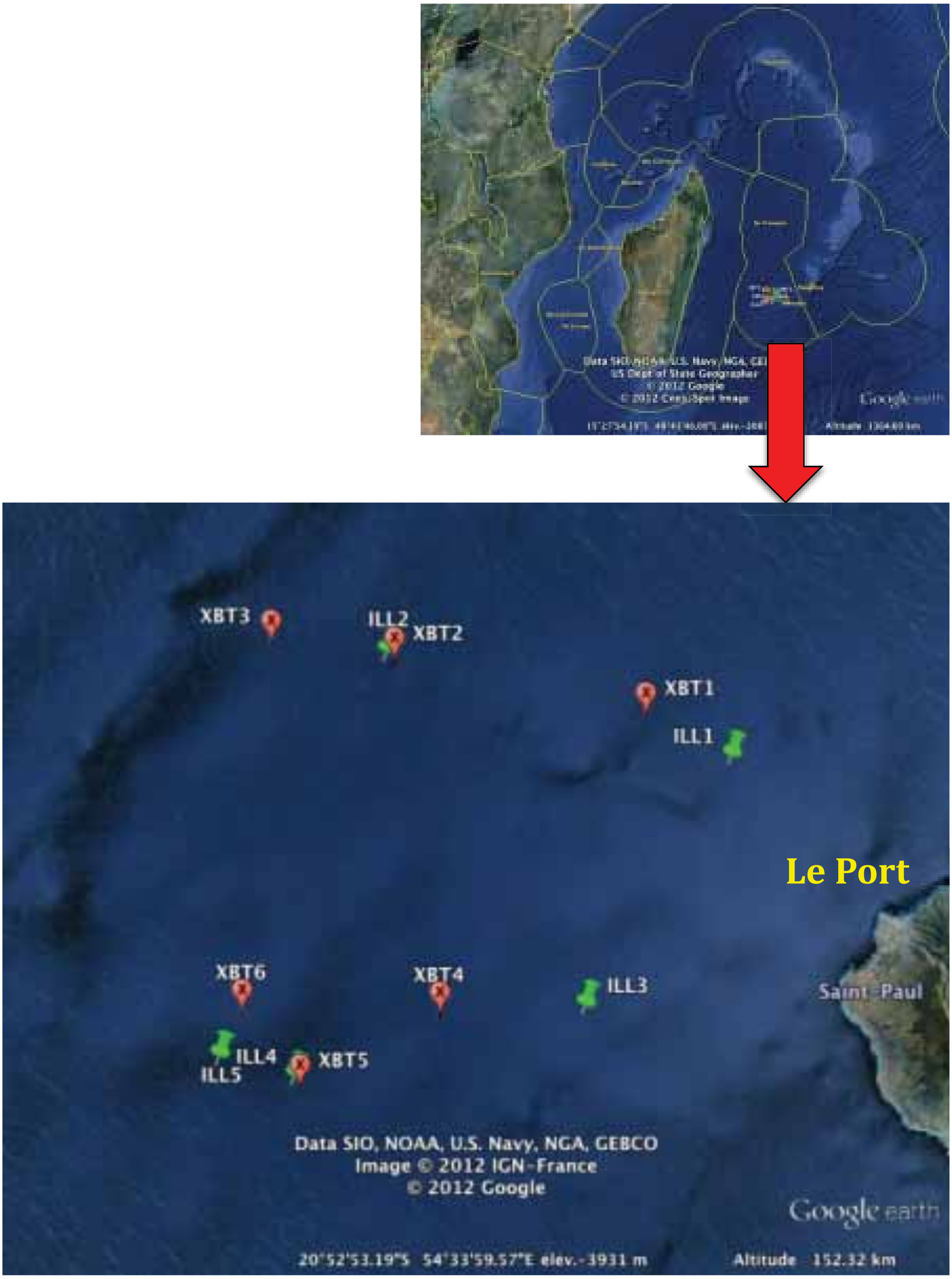


Figure 2 – Positions of longline sets (ILL – symbol green) and XBT launches (XBT – symbol red) carried out by during the ILL training cruise.

3 Material and methods

3.1 Oceanographic observations

Hydrological observations were carried out using Sippican's Expendable Bathythermograph (XBT probes producing temperature – depth profiles.

The design of the Sippican's system is displayed on the figure 3. XBT profiles were analysed on board by running the WinMK21 software.

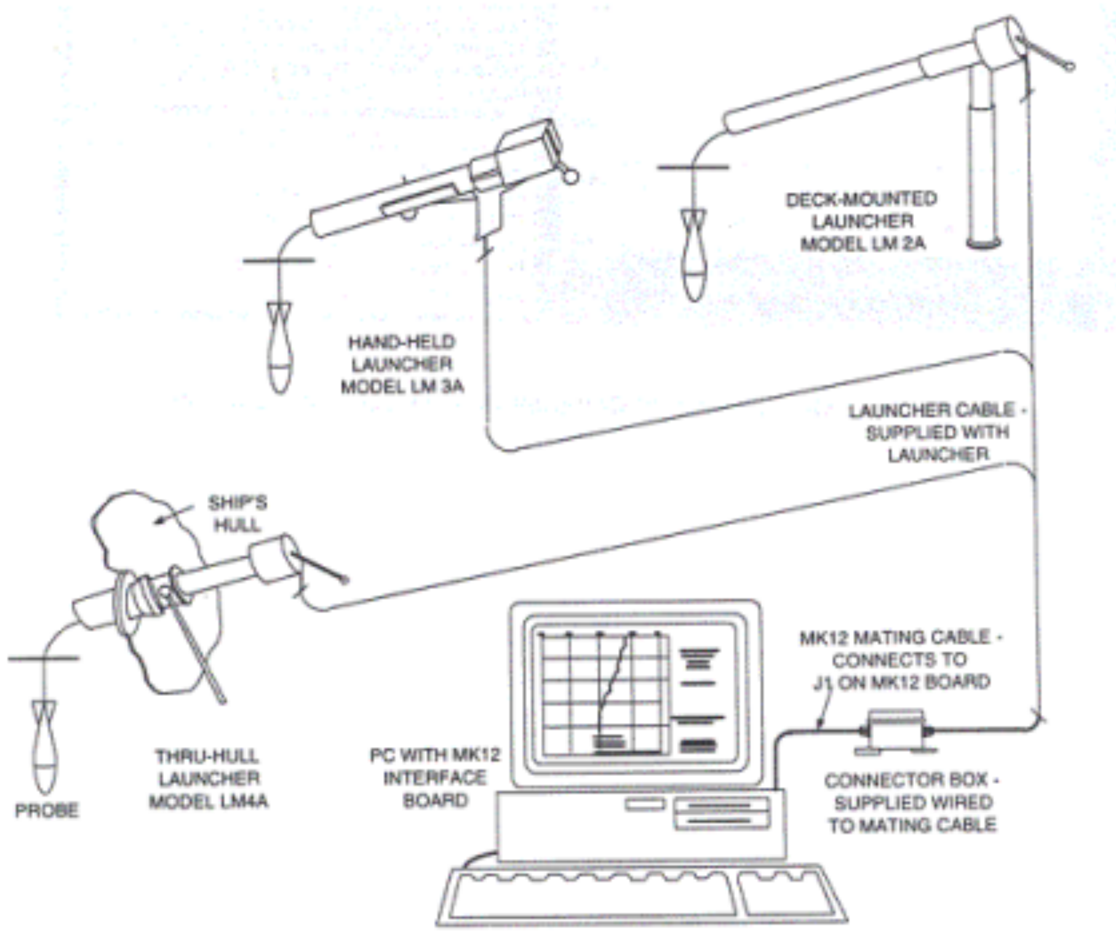


Figure 3 – Design of the Sippican's XBT system used to carry out temperature – depth profiles (Source : http://www.sippican.com).

3.2 Biological observations

All fish were measured with a calliper (for straight length measurements) and measuring tape (curved length measurements) with precision to 1 cm. Several types of morphometric measurements were taken to develop relationships for further key conversions of size to size. The following measurements were taken:

Tuna: straight fork length (FL); curved fork length (CFL); straight predorsal length (PDL), and straight pectoral-anal length (PAL), (Figure 4 A).

Billfish: curved total length (TL); straight lower jaw-fork length (LJFL), curved lower jaw-fork length (CLJFL), curved eye-fork length (EFL), curved pectoral-anal length (PAL), (Figure 4 B).

Sharks: curved total length (TL); curved fork length (FL); curved standard length (SL); curved inter-dorsal length (IDL); straight length of the rear margin of the left and the right pectoral fin P1P (L) and P1P (R) respectively, (Figure 4 C).

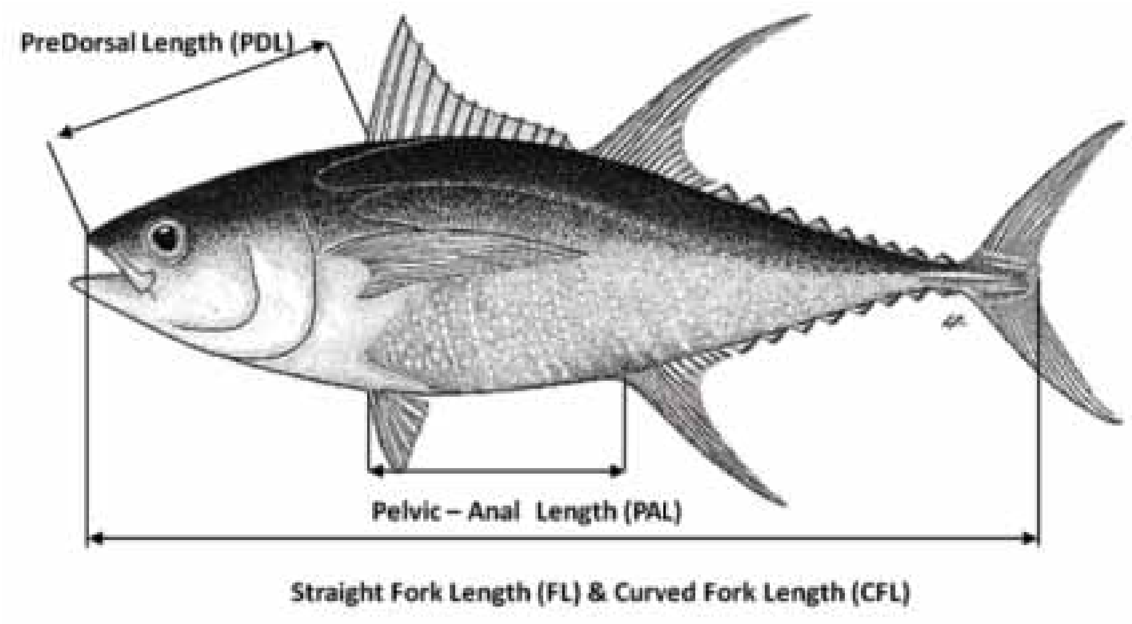
Skates: straight total length (TL), straight disk width (DW) and straight disk length (DL).

Other species: straight fork length (FL).

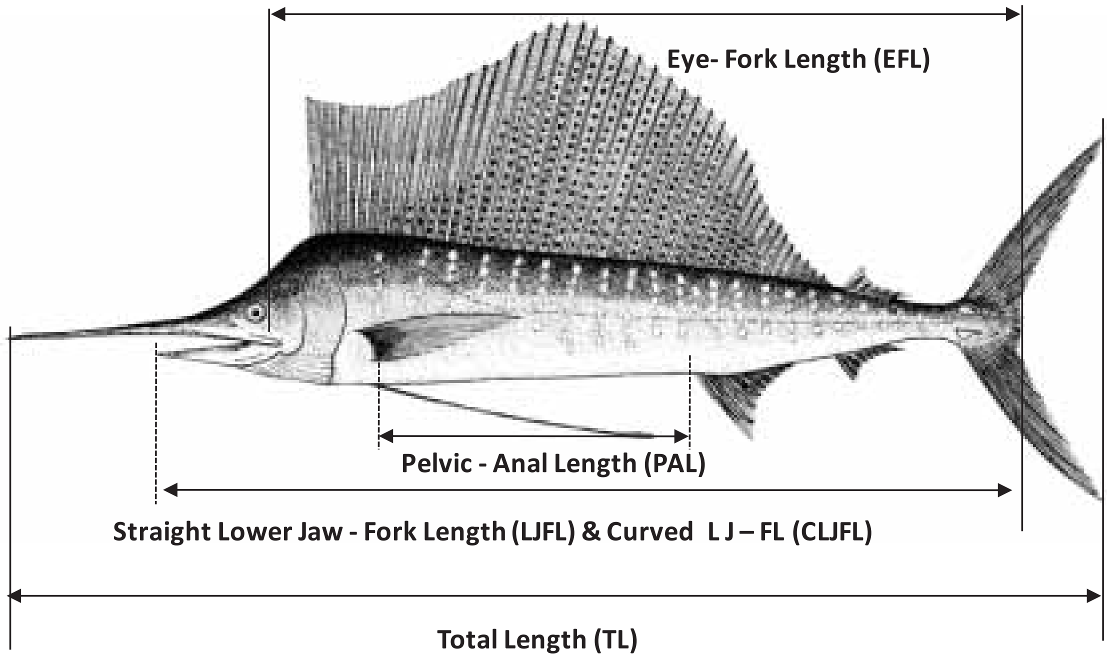
Sex and maturity stage: of fish were recorded, gonad were weighed. Liver was weighed in tuna.

3.3 Fishing experiments using instrumented longline

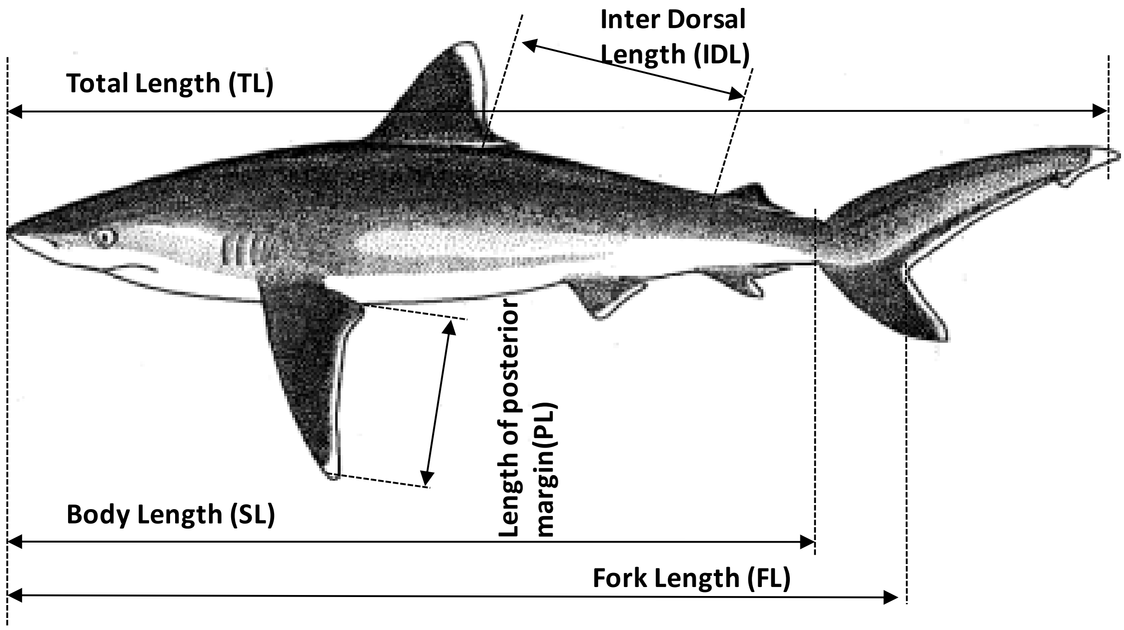
The F/V « Brahma » is a longliner of ~ 25 m LOA. The crew was composed of 5 persons including the captain. The longliner is equipped with a nylon monofilament mainline stocked on a spool manufactured by Lindgren Pitman™. The line capacity of the spool is ~ 60 miles for a line diameter of ~ 3.4 mm (Figure 5). This spool is also used for the hauling of the mainline. The longline is a string of hooks attached with a snap to the mainline, which is maintained at the surface of the ocean by buoys also attached to the mainline at regular intervals. A transmitter buoy is fastened at each end of the mainline (Figure 6). During our fishing experiments, the mainline was attached to 10-m polypropylene float lines with 10-l floats at the surface. Monofilament branch lines were 12-m long and snapped on at a constant time interval for a given set. Each brancline is equipped with a weight of 60 g and a circle hook with an offset of 12°. Circle hooks (Figure 6) were used because their lower impact on potential capture of non-target species (mainly sea turtles). Squid (*Ilex* spp.) were used as bait.



A – Tuna and tuna like species



B – Billfish measurements



C - Sharks measurements

Figure 4 – Details of length measurements for tuna, billfish and shark.

For each set, some baskets (the part of the longline between two successive floats) were equipped with time depth recorders (Figure 7). TDRs were programmed to record fishing depth once per minute. The TDRs were placed at the mid-point on the basket mainline which corresponds to its maximum depth. For one experiment the longline behaviour was studied with several TDRs close to each hook of a given basket and with GPS buoys to measure simultaneously the variation of the sag ratio.

Each branch line was equipped with a hook timer (Figure 8). Hook timers indicate elapsed time in minutes between the hooking contact (triggered hook timer with or without capture) of fish on the line and landing on deck, from which the time of the hooking contact is deduced. Hooking depths will be inferred from hook depths at hooking times estimated by a longline shape model.

Figure 5 - The mainline spool by Lindgren Pitman ™ installed on board the longliner

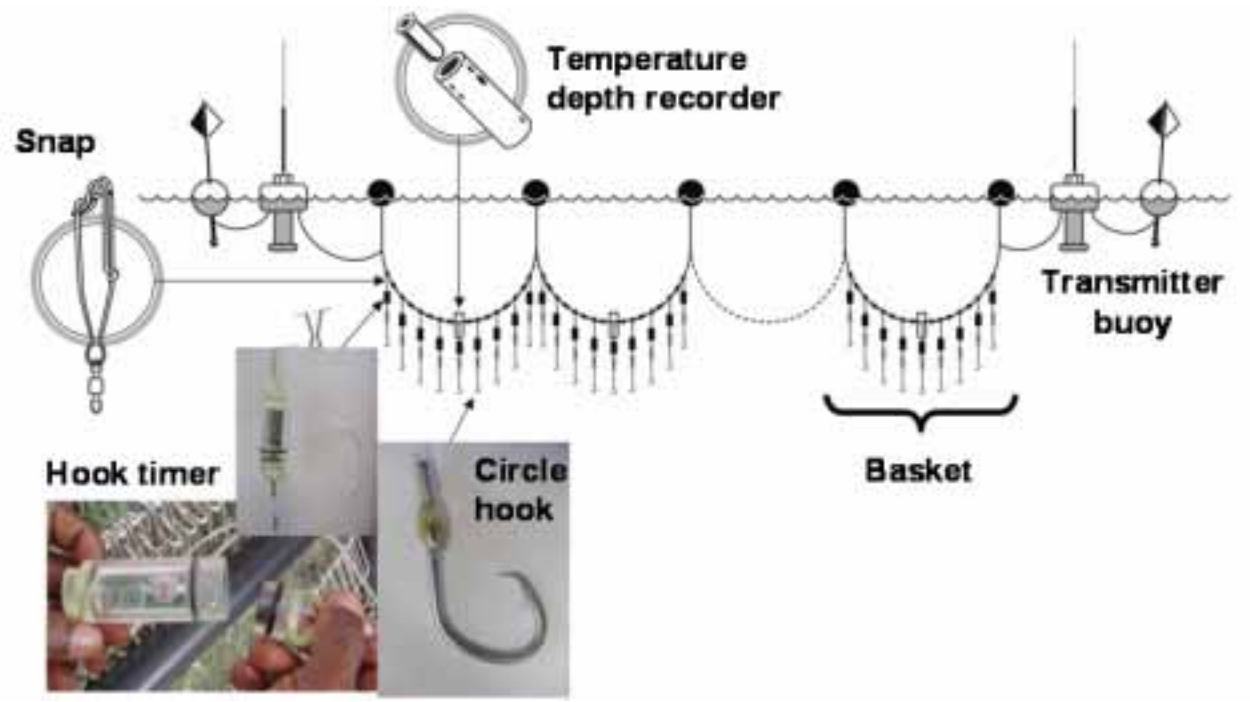


Figure 6 ‑ The instrumented longline deployed during the SWIOFP ILL training cruise

Figure 7 – TDRs ready to be deployed on the mainline

Figure 8 - Set of branchlines equipped with hook timers in its box.

4 Results

4.1 Hydrological situation in the area

Temperature – depth profiles were imported in a geolocalized oceanograhic database and mapped by using the Ocean Data View 4.5 software (http://odv.awi.de/). Sea surface temperature during the cruise reached about 29°C. Temperature vertical profiles displayed a weak thermocline between 50 m and 70 m depth followed by a linear decrease of temperature values until 450 m where the water temperature was about 12.5° C (Figure 9). Kriging maps produced from these profiles showed fronts of temperature at 50 m with a decrease of the temperature from North to South (Figure 9) and from East to West at latitudes south to 21°. However, for the 100 m isobath the temperature of the water mass appeared as homogeneous with a temperature of about 24.5 °C (Figure 9).

4.2 Instrumented longline fishing operations

General presentation of longline fishing operations

Detailed information on characteristics of the instrumented longline deployment for each set are presented in the Table 2 A, B, C, D, E. A summary of numbers of sets realized, number of baskets, hooks, hook timers and temperature depth recorders deployed is presented in the Table 3.

The 5 sets realized represented 182 baskets, 1957 hooks (circle and tuna hooks) and 58 TDR profiles. At the beginning of the cruise, the theoretical number of hooks per basket was 10 (*i.e* the number of interval between floats was 11) while 14 and 16 were used for the fishing operations 4 and 5, respectively. As the time interval between hooks and the setting speed were the same for the different sets the increase of the number of hooks per basket generated an increase of the mainline length per basket. Then, the idea was to illustrate for trainees the theoretical relationship between the mainline length per basket and the maximum fishing depth for a given sag ratio. This strategy was used as the F/V "Brahma" was not equipped with a line shooter normally used the set the longline deeper with a given ratio usually ranged between 60% and 85%.

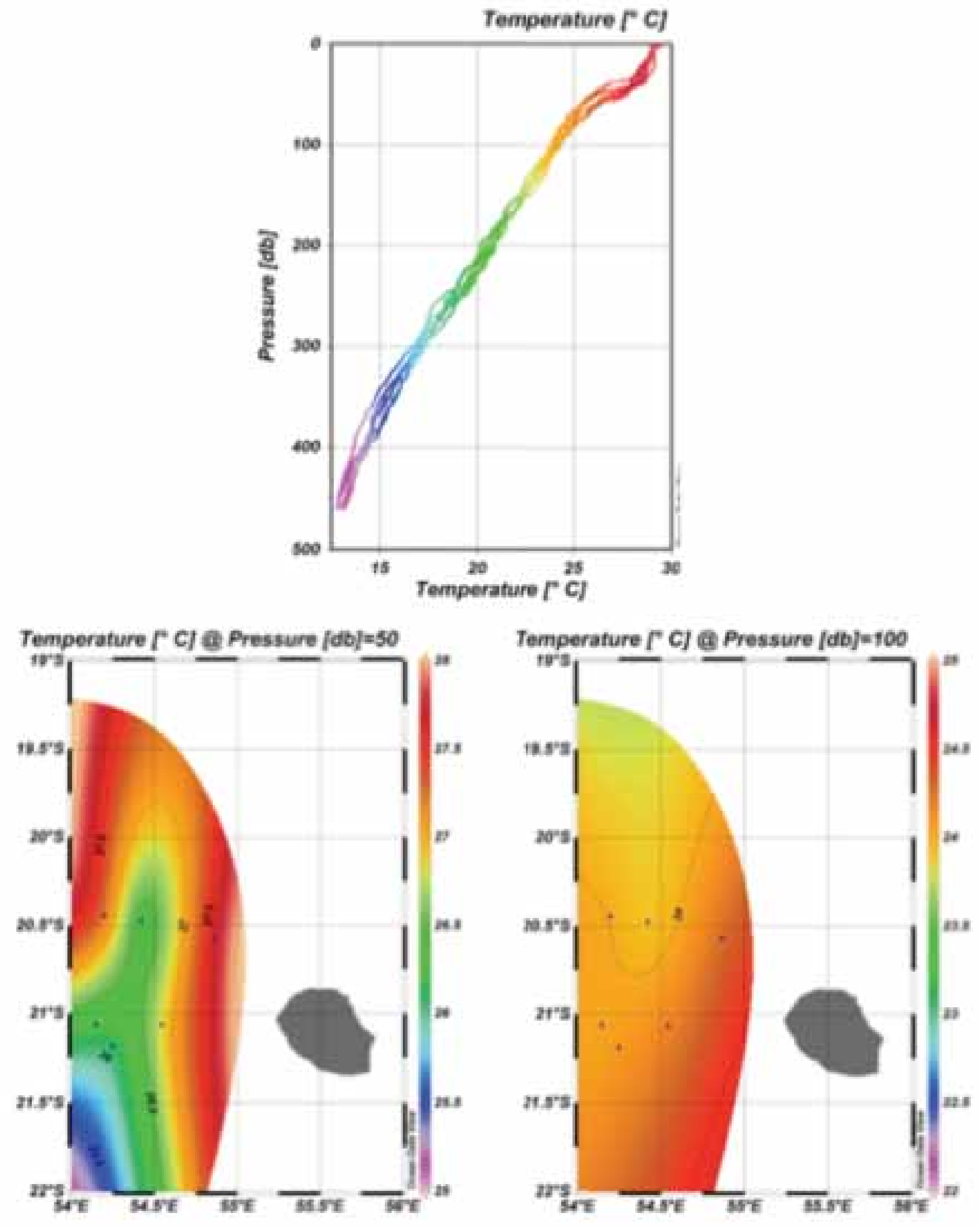

Temperature [° C]
Pressure [db]
0
100
200
300
400
500
15
20
25
30
Temperature [° C]
Temperature [° C] @ Pressure [db]=50
Temperature [° C] @ Pressure [db]=100
19°S
19.5°S
20°S
20.5°S
21°S
21.5°S
22°S
54°E
54.5°E
55°E
55.5°E
56°E

Figure 9 – Depth – temperature XBT profiles obtained during the ILL training cruise (top). Kriging map of the water temperature at 50 m depth (down left) and 300 m (down right) obtained from XBT profiles.

Table 2 – Detailed characteristics of the instrumented longline deployment

A – Set 1

ILL1 23/02/11

Boat speed (knts) = 6

LL set tied YES

N° Basket	N. Int	Hook type: Circle	Tuna	N. hooks	N. HTs	FL (m)	N°TDR	TBH (s)	TBF (s)	DBF (m)	LLBF (m)	SR(%)	Bait	TDR depth (m): Min	Max
1	11		9	9	9	10		15	165	509	524.7	97	Squid		
2	11		10	10	10	10		15	165	509	519.4	98	Squid		
3	11	3	6	9	9	10		15	165	509	519.4	98	Squid		
4	11	9		9	9	10		15	165	509	519.4	98	Squid		
5	11	7		7	7	10		15	165	509	519.4	98	Squid		
6	11	10		10	10	10		15	165	509	519.4	98	Squid		
7	11	8		8	8	10		15	165	509	519.4	98	Squid		
8	11	8		8	8	10	9	15	165	509	519.4	98	Squid	32	67
9	11	9		9	9	10		15	165	509	519.4	98	Squid		
10	11	10		10	10	10		15	165	509	519.4	98	Squid		
11	11	10		10	10	10	14	15	165	509	519.4	98	Squid	23	85
12	11	9		9	9	10		15	165	509	519.4	98	Squid		
13	11	5	5	10	10	10		15	165	509	519.4	98	Squid		
14	11		10	10	10	10	15	15	165	509	519.4	98	Squid	29	75
15	11		10	10	10	10		15	165	509	519.4	98	Squid		
16	11		8	8	8	10		15	165	509	519.4	98	Squid		
17	11		10	10	10	10	16	15	165	509	519.4	98	Squid	28	78
18	11		10	10	10	10		15	165	509	519.4	98	Squid		
19	11		10	10	10	10		15	165	509	519.4	98	Squid		
20	11		10	10	10	10		15	165	509	519.4	98	Squid		
21	11		9	9	9	10		15	165	509	519.4	98	Squid		
22	11		9	9	9	10		15	165	509	519.4	98	Squid		
23	11		10	10	10	10	17	15	165	509	519.4	98	Squid	30	100
24	11	10		10	10	10		15	165	509	519.4	98	Squid		
25	11	10		10	10	10		15	165	509	519.4	98	Squid		
26	11	10		10	10	10	18	15	165	509	519.4	98	Squid	28	91
27	11	7		7	7	10		15	165	509	519.4	98	Squid		
28	11	10		10	10	10		15	165	509	519.4	98	Squid		
29	11	7		7	7	10		15	165	509	519.4	98	Squid		
30	11	8		8	8	10		15	165	509	519.4	98	Squid		
31	11	8		8	8	10		15	165	509	519.4	98	Squid		
32	11	6		6	6	10	19	15	165	509	519.4	98	Squid	39	87
33	11	10		10	10	10		15	165	509	519.4	98	Squid		
34	11	10		10	10	10	20	15	165	509	519.4	98	Squid	51	115
35	11	9		9	9	10		15	165	509	519.4	98	Squid		
36	11	8		8	8	10		15	165	509	519.4	98	Squid		
37	11	8		8	8	10	21	15	165	509	519.4	98	Squid	59	109
38	11	9		9	9	10		15	165	509	519.4	98	Squid		
39	11	10		10	10	10		15	165	509	519.4	98	Squid		
40	11	10		10	10	10		15	165	509	519.4	98	Squid		

N. Hooks = number of hooks per basket (circle hook + tuna hooks),
N. HTs = number of hook timers deployed per basket
FL (m) = length of the floatline
N° TDR = N° of the temperature depth recorder
TBH (s) = time between hooks
DBF (m) = horizontal distance between floats
LLBF (m) = mainline length between floats
SR (%) = sag ratio = DBF/LLBF
TDR depth = min and max values of depth recorded at the middle of baskets

Table 2 (Cont'd) – Detailed characteristics of the instrumented longline deployment

B – Set 2

ILL2 24/02/11

Boat speed (knts) = 6

LL set tied YES

N° Basket	N. Int	Hook type: Circle	Hook type: Tuna	N. hooks	N. HTs	FL (m)	N°TDR	TBH (s)	TBF (s)	DBF (m)	LLBF (m)	SR(%)	Bait	TDR depth (m): Min	TDR depth (m): Max
1	11		8	8	8	10		15	165	509	519.4	98	Squid		
2	11		9	9	9	10		15	165	509	519.4	98	Squid		
3	11		10	10	10	10		15	165	509	519.4	98	Squid		
4	11		9	9	9	10		15	165	509	519.4	98	Squid		
5	11		10	10	10	10	6	15	165	509	519.4	98	Squid	70	130
6	11	7		7	7	10		15	165	509	519.4	98	Squid		
7	11	10		10	10	10		15	165	509	519.4	98	Squid		
8	11	9		9	9	10	8	15	165	509	519.4	98	Squid	72	130
9	11	10		10	10	10		15	165	509	519.4	98	Squid		
10	11	10		10	10	10		15	165	509	519.4	98	Squid		
11	11		10	10	10	10		15	165	509	519.4	98	Squid		
12	11		10	10	10	10		15	165	509	519.4	98	Squid		
13	11		9	9	9	10	10	15	165	509	519.4	98	Squid	65	128
14	11		10	10	10	10		15	165	509	519.4	98	Squid		
15	11		7	7	7	10		15	165	509	519.4	98	Squid		
16	11	8		8	8	10		15	165	509	519.4	98	Squid		
17	11	10		10	10	10		15	165	509	519.4	98	Squid		
18	11	9		9	9	10		15	165	509	519.4	98	Squid		
19	11	10		10	10	10		15	165	509	519.4	98	Squid		
20	11	9		9	9	10	11	15	165	509	519.4	98	Squid	67	136
21	11		8	8	8	10		15	165	509	519.4	98	Squid		
22	11		8	8	8	10		15	165	509	519.4	98	Squid		
23	11		10	10	10	10	12	15	165	509	519.4	98	Squid	51	116
24	11		10	10	10	10		15	165	509	519.4	98	Squid		
25	11		9	9	9	10		15	165	509	519.4	98	Squid		
26	11	8		8	8	10		15	165	509	519.4	98	Squid		
27	11	10		10	10	10		15	165	509	519.4	98	Squid		
28	11	10		10	10	10	13	15	165	509	519.4	98	Squid	52	127
29	11	10		10	10	10		15	165	509	519.4	98	Squid		
30	11	10		10	10	10		15	165	509	519.4	98	Squid		
31	11		8	8	8	10		15	165	509	519.4	98	Squid		
32	11		10	10	10	10		15	165	509	519.4	98	Squid		
33	11		9	9	9	10		15	165	509	519.4	98	Squid		
34	11		10	10	10	10	22	15	165	509	519.4	98	Squid	58	130
35	11		8	8	8	10		15	165	509	519.4	98	Squid		
36	11	9		9	9	10		15	165	509	519.4	98	Squid		
37	11	7		7	7	10		15	165	509	519.4	98	Squid		
38	11	8		9	8	10	23	15	165	509	519.4	98	Squid	64	129
39	11	10		10	10	10		15	165	509	519.4	98	Squid		
40	11	10		10	10	10		15	165	509	519.4	98	Squid		

Table 2 (Cont'd) – Detailed characteristics of the instrumented longline deployment

C – Set 3

ILL3 28/02/11

Boat speed (knts) = 6
LL set tied YES

N° Basket	N. int	Hook type: Circle	Hook type: Tuna	N. hooks	N. HTs	FL (m)	N°TDR	TBH (s)	TBF (s)	DBF (m)	LLBF (m)	SR(%)	Bait	TDR depth (m): Min	TDR depth (m): Max
1	11	10		10	10	10		15	165	509	519.4	98	Squid		
2	11	8	2	10	10	10	8	15	165	509	519.4	98	Squid	70	150
3	11		8	8	8	10		15	165	509	519.4	98	Squid		
4	11		10	10	10	10	10	15	165	509	519.4	98	Squid	57	156
5	11	10		10	10	10		15	165	509	519.4	98	Squid		
6	11	10		10	10	10		15	165	509	519.4	98	Squid		
7	11		10	10	10	10		15	165	509	519.4	98	Squid		
8	11		10	10	10	10		15	165	509	519.4	98	Squid		
9	11	6	3	9	9	10	11	15	165	509	519.4	98	Squid	50	192
10	11	6		6	6	10		15	165	509	519.4	98	Squid		
11	11	10		10	10	10	12	15	165	509	519.4	98	Squid	50	153
12	11		9	9	9	10		15	165	509	519.4	98	Squid		
13	11		10	10	10	10	13	15	165	509	519.4	98	Squid	50	163
14	11	7	2	9	9	10		15	165	509	519.4	98	Squid		
15	11	10		10	10	10		15	165	509	519.4	98	Squid		
16	11	9		9	9	10		15	165	509	519.4	98	Squid		
17	11		10	10	10	10	14	15	165	509	519.4	98	Squid	47	154
18	11		10	10	10	10		15	165	509	519.4	98	Squid		
19	11		9	9	9	10		15	165	509	519.4	98	Squid		
20	11	9		9	9	10		15	165	509	519.4	98	Squid		
21	11	9		9	9	10		15	165	509	519.4	98	Squid		
22	11	10		10	10	10	15	15	165	509	519.4	98	Squid	40	116
23	11		7	7	7	10		15	165	509	519.4	98	Squid		
24	11		10	10	10	10		15	165	509	519.4	98	Squid		
25	11		9	9	9	10	16	15	165	509	519.4	98	Squid	48	106
26	11	10		10	10	10		15	165	509	519.4	98	Squid		
27	11	10		10	10	10		15	165	509	519.4	98	Squid		
28	11	10		10	10	10	17	15	165	509	519.4	98	Squid	49	107
29	11		8	8	8	10		15	165	509	519.4	98	Squid		
30	11		10	10	10	10		15	165	509	519.4	98	Squid		
31	11		10	10	10	10	18	15	165	509	519.4	98	Squid	59	121
32	11		10	10	10	10		15	165	509	519.4	98	Squid		
33	11	10		10	10	10	20	15	165	509	519.4	98	Squid	60	108
34	11	10		10	10	10		15	165	509	519.4	98	Squid		
35	11	10		10	10	10	22	15	165	509	519.4	98	Squid	52	115
36	11	10		10	10	10		15	165	509	519.4	98	Squid		
37	11	10		10	10	10		15	165	509	519.4	98	Squid		
38	11	2	4	6	6	10		15	165	509	519.4	98	Squid		
39	11		9	9	9	10	21	15	165	509	519.4	98	Squid	90	160
40	11		10	10	10	10		15	165	509	519.4	98	Squid		
41	11		10	10	10	10	23	15	165	509	519.4	98	Squid	110	208
42	11		8	8	8	10		15	165	509	519.4	98	Squid		

Table 2 (Cont'd) – Detailed characteristics of the instrumented longline deployment

D – Set 4

ILL4 01/03/11

Boat speed (knts) = 6
LL set tied YES

N° Basket	N. Int	Hook type: Circle	Hook type: Tuna	N. hooks	N. HTs	FL (m)	N°TDR	TBH (s)	TBF (s)	DBF (m)	LLBF (m)	SR(%)	Bait	TDR depth (m) Min	TDR depth (m) Max
1	15		14	14	14	20		15	695	709.2	723.7	98	Squid		
2	15	13	1	14	14	20	6	15	695	709.2	723.7	98	Squid	143	190
3	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
4	15	1	12	13	13	20	8	15	695	709.2	723.7	98	Squid	109	152
5	15		13	13	13	20		15	695	709.2	723.7	98	Squid		
6	15	14		14	14	20	10	15	695	709.2	723.7	98	Squid	79	144
7	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
8	15	4	10	14	14	20	11	15	695	709.2	723.7	98	Squid	90	149
9	15	5	9	14	14	20		15	695	709.2	723.7	98	Squid		
10	15	12	2	14	14	20	12	15	695	709.2	723.7	98	Squid	30	113
11	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
12	15		14	14	14	20	13	15	695	709.2	723.7	98	Squid	37	139
13	15		13	13	13	20		15	695	709.2	723.7	98	Squid		
14	15		14	14	14	20	14	15	695	709.2	723.7	98	Squid	37	115
15	15	13		13	13	20		15	695	709.2	723.7	98	Squid		
16	15	14		14	14	20	15	15	695	709.2	723.7	98	Squid	43	99
17	15		13	13	13	20		15	695	709.2	723.7	98	Squid		
18	15		12	12	12	20	16	15	695	709.2	723.7	98	Squid	45	113
19	15		14	14	14	20		15	695	709.2	723.7	98	Squid		
20	15	13		13	13	20	17	15	695	709.2	723.7	98	Squid	49	109
21	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
22	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
23	15		14	14	14	20	18	15	695	709.2	723.7	98	Squid	69	139
24	15		7	7	7	20		15	695	709.2	723.7	98	Squid		
25	15		14	14	14	20	20	15	695	709.2	723.7	98	Squid	80	134
26	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
27	15	14		14	14	20	21	15	695	709.2	723.7	98	Squid	76	130
28	15		11	11	11	20		15	695	709.2	723.7	98	Squid		
29	15		14	14	14	20		15	695	709.2	723.7	98	Squid		
30	15	14		14	14	20	22	15	695	709.2	723.7	98	Squid	116	180
31	15	14		14	14	20		15	695	709.2	723.7	98	Squid		
32	15	12		12	12	20	23	15	695	709.2	723.7	98	Squid	238	285

E – Set 5

ILL5 02/03/11

Boat speed (knts) = 6
LL set tied YES

N° Basket	N. Int	Hook type: Circle	Hook type: Tuna	N. hooks	N. HTs	FL (m)	N°TDR	TBH (s)	TBF (s)	DBF (m)	LLBF (m)	SR(%)	Bait	TDR depth (m) Min	TDR depth (m) Max
1	17	16		16	16	20		MKE	15	787	803.1	98	Squid		
2	17		16	16	16	20	6	MKE	15	787	803.1	98	Squid	159	200
3	17	16		16	16	20	8	MKE	15	787	803.1	98	Squid	137	166
4	17		15	15	15	20		MKE	15	787	803.1	98	Squid		
5	17	16		16	16	20	10	MKE	15	787	803.1	98	Squid	117	172
6	17		16	16	16	20		MKE	15	787	803.1	98	Squid		
7	17	16		16	16	20	11	MKE	15	787	803.1	98	Squid	119	139
8	17		16	16	16	20		MKE	15	787	803.1	98	Squid		
9	17	16		16	16	20	12	MKE	15	787	803.1	98	Squid	115	141
10	17		16	16	16	20		MKE	15	787	803.1	98	Squid		
11	17	8		8	8	20		MKE	15	787	803.1	98	Squid		
12	17	16		16	16	20	13	MKE	15	787	803.1	98	Squid	116	165
13	17		11	11	11	20		MKE	15	787	803.1	98	Squid		
14	17		16	16	16	20	14	MKE	15	787	803.1	98	Squid	112	167
15	17	16		16	16	20		MKE	15	787	803.1	98	Squid		
16	17	16		16	16	20	15	MKE	15	787	803.1	98	Squid	106	165
17	17		15	15	15	20		MKE	15	787	803.1	98	Squid		
18	17		13	13	13	20	16	MKE	15	787	803.1	98	Squid	111	161
19	17	16		16	16	20		MKE	15	787	803.1	98	Squid		
20	17	16		16	16	20	17	MKE	15	787	803.1	98	Squid	115	165
21	17		9	9	9	20		MKE	15	787	803.1	98	Squid		
22	17		16	16	16	20		MKE	15	787	803.1	98	Squid		
23	17	16		16	16	20		MKE	15	787	803.1	98	Squid		
24	17	7		7	7	20		MKE	15	787	803.1	98	Squid		
25	17		16	16	16	20		MKE	15	787	803.1	98	Squid		
26	17		16	16	16	20	21	MKE	15	787	803.1	98	Squid	160	260
27	17	7		7	7	20		MKE	15	787	803.1	98	Squid		
28	17	15		15	15	20	22	MKE	15	787	803.1	98	Squid	188	329

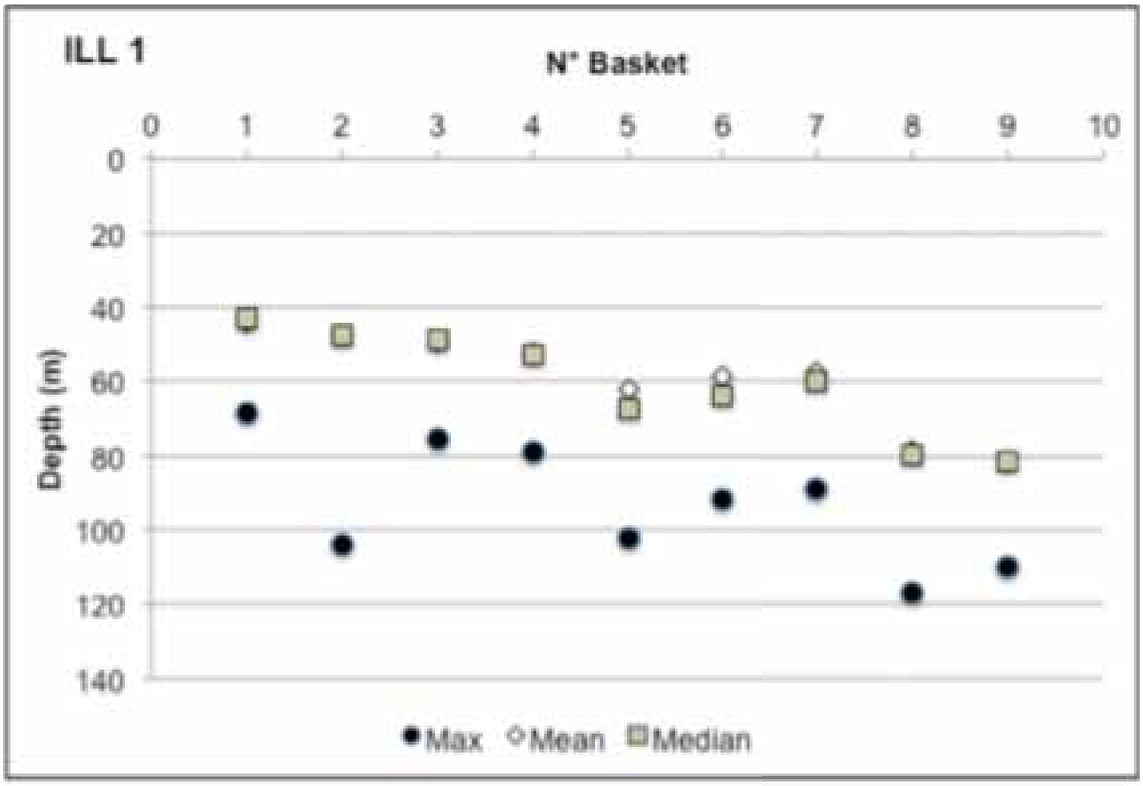
Table 3 – Summary of sets, baskets, hooks and hook timers and temperature depth recorders deployed during the SWIOFP ILL training cruise.

N° LL	N. baskets	N. Hooks	N. HTs	Number of TDRs deployed
1	40	364	364	9
2	40	367	367	8
3	42	394	394	14
4	32	428	428	15
5	28	404	404	12
Total	182	1957	1957	58

Maximum fishing depth

On figures 10 A to E the maximum, the mean and the median values of depth recorded by TDRs for each fishing experiments are represented. Maximum values ranged from 60 m to 200 m displayed highest intraset variations compared to mean and median values. Linear empirical relationship between these variables indicated that the difference between maximum depth values and mean depth values were about ~ 45 m (R^2 = 69%, $P < 0.001$) while the difference between mean depth and median depth was positive for mean depth less than 62 m and negative otherwise (R^2 = 96%, $P < 0.001$), (Figure 11).

The supposed relationship between the maximum fishing depth and the length of the mainline between floats we expected to find by increasing the number of hooks per basket is highlighted on the Figure 12. The slope of the linear relationship indicates an depth increase of 18 m for each 100 m increase of the mainline length between floats. Moreover, it must be noted that the variation amplitude of the median values was almost similar (~ 80 m) for each mainline length between floats experimented (Figure 12). This result traduces the strong effect of the environment on the mainline at small scales for a given longline deployment strategy.



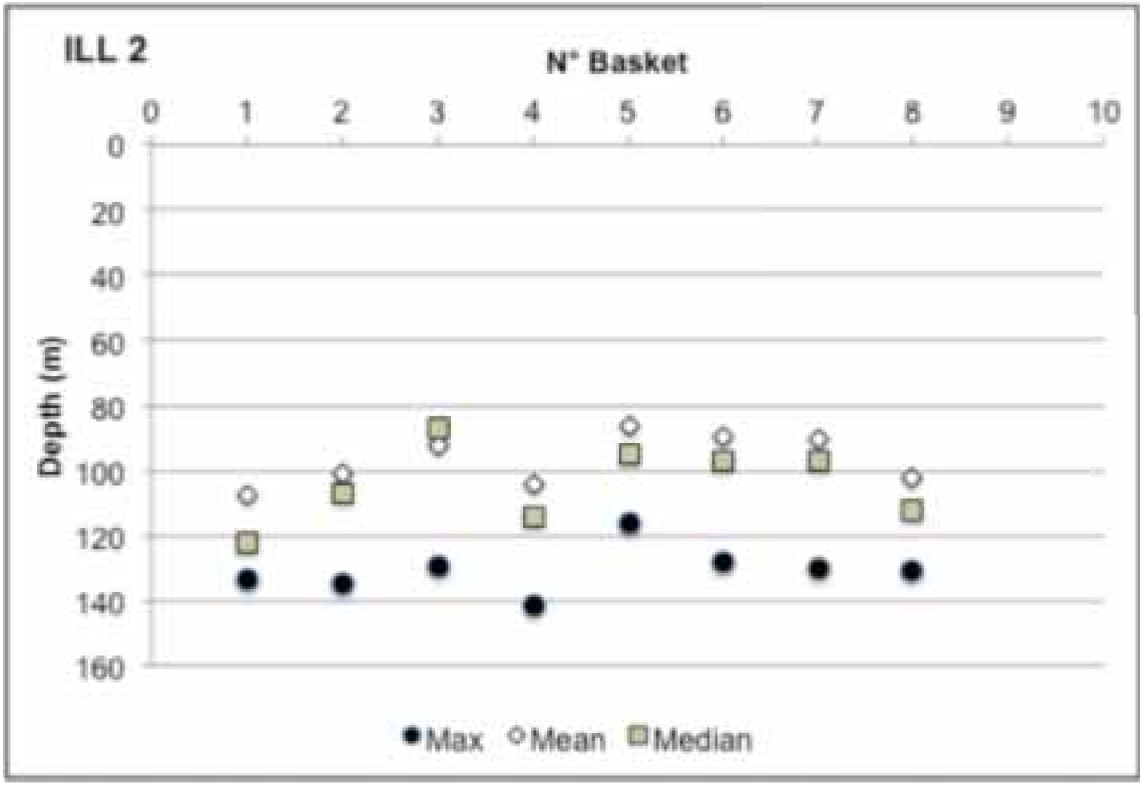


Figure 10 A, B – Maximum, mean and median of depth series recorded by TDRs on baskets of the instrumented longline fishing experiments 1 (ILL 1) and 2 (ILL2).

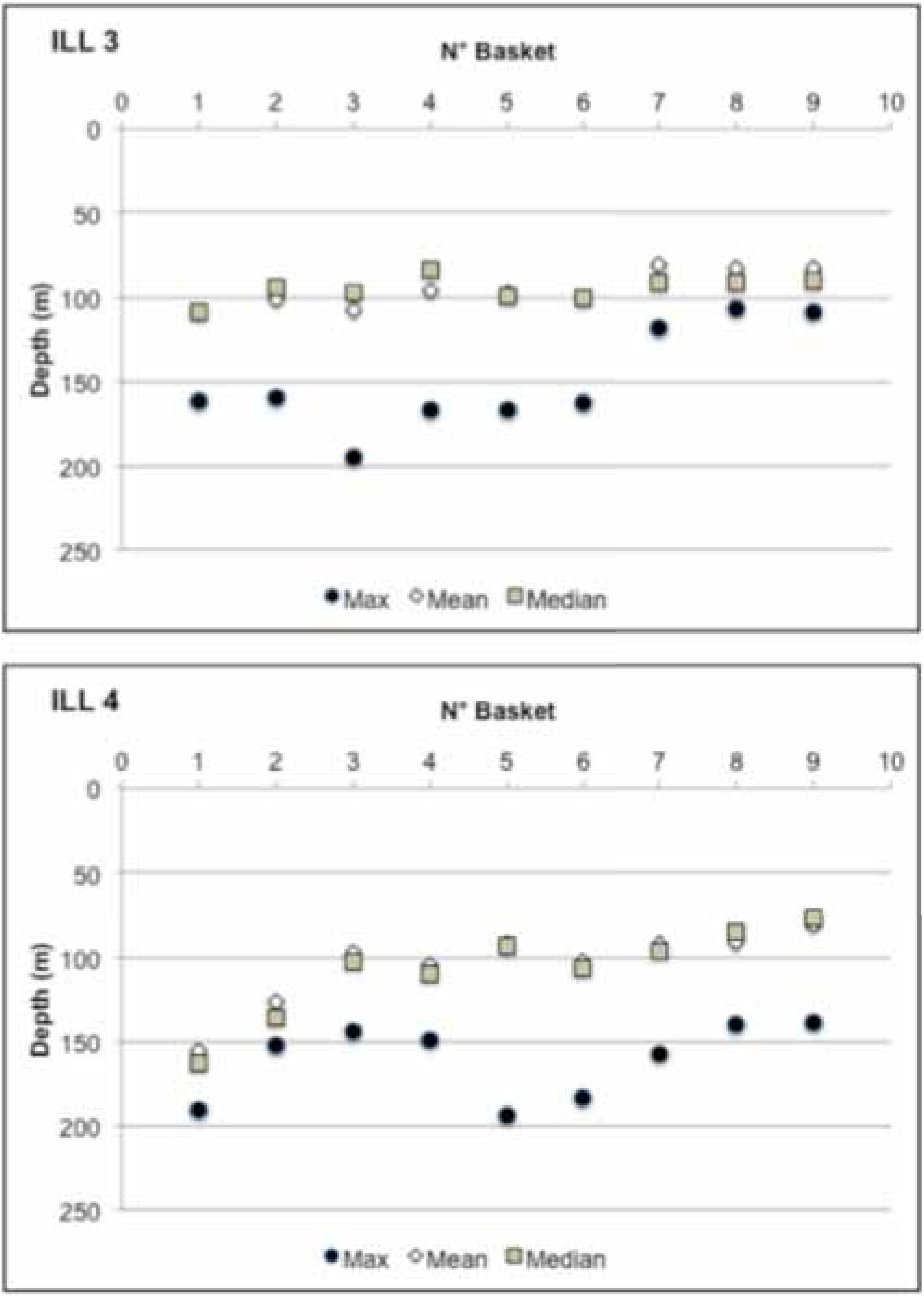


Figure 10 C, D – Maximum, mean and median of depth series recorded by TDRs on baskets of the instrumented longline fishing experiments 3 (ILL 3) and 4 (ILL4).

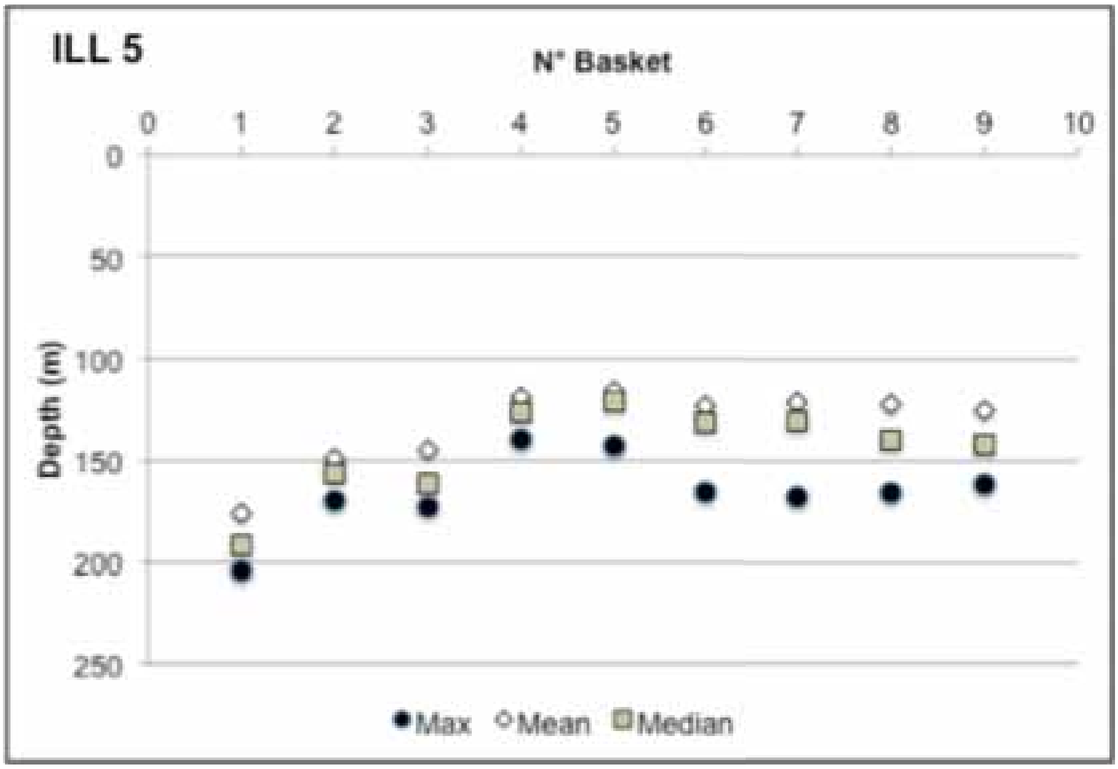


Figure 10 E – Maximum, mean and median of depth series recorded by TDRs on baskets of the instrumented longline fishing experiments 5 (ILL 5).

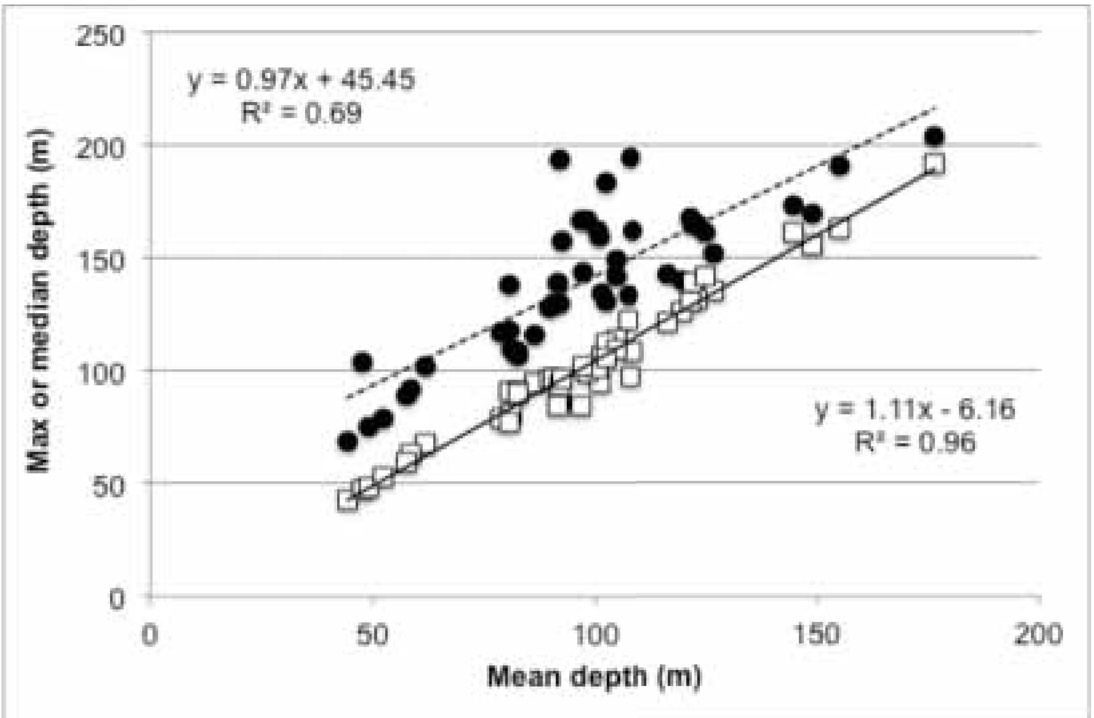


Figure 11 – Empirical linear relationships between the mean depth values (horizontal axis) and the maximum or the median depth values (vertical axis).

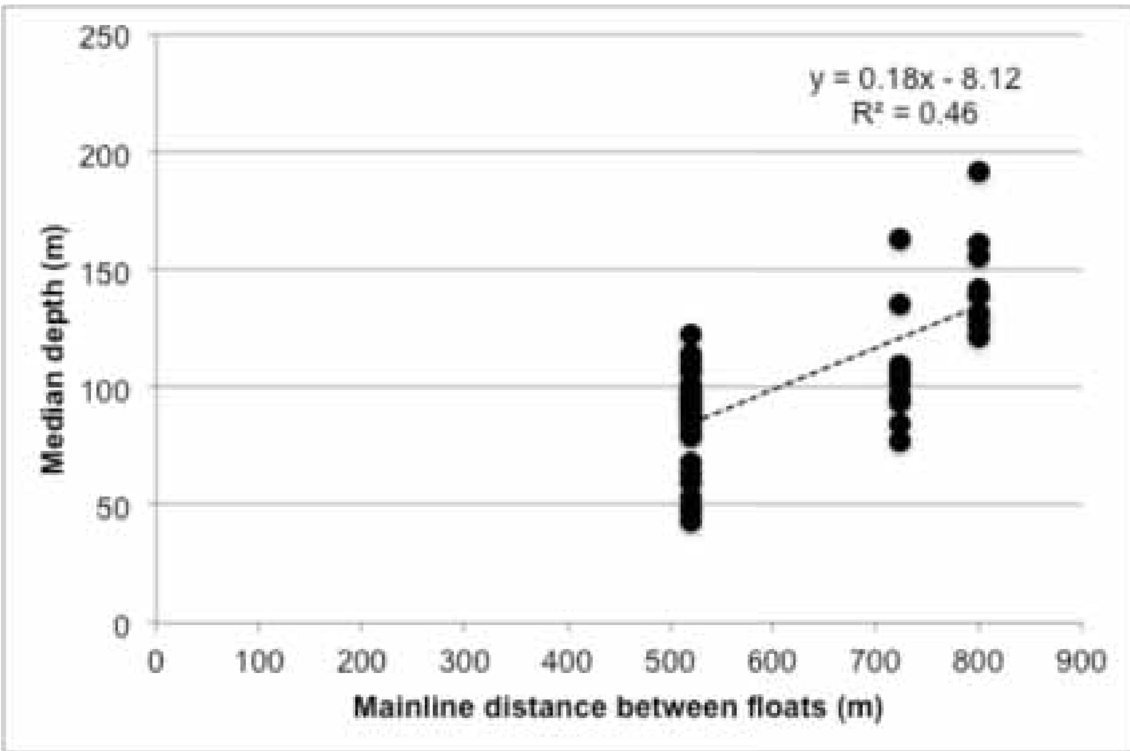


Figure 12 – Empirical linear relationship between the median depth recorded on baskets (m) and the mainline distance between floats.

4.3 Hooking responses and capture

During this cruise of five instrumented longline sets, a total of 92 hooking responses (HR) was recorded from hook timers (ranged from 10 to 39 HR per set). Among these HR, 49 corresponded to capture (hooking success), (Tab. 4). The level of the hooking efficiency for the 5 sets estimated at the ratio between the number of hooking success and the number of hooking contact was 53%.

Table 4 – Number of hooking responses and hooking success per set recorder during the cruise.

	ILL1	ILL2	ILL3	ILL4	ILL5	Total
Hooking responses	39	11	10	18	14	92
Hooking success	9	7	7	13	13	49

These 49 hooking success corresponded to 9 large pelagic species (Tab. 5). Among these species, three of them (swordfish, lancetfish and blueshark) represented 80%. The swordfish (*Xiphias gladius*) and the lancetfish (*Alepisaurus ferox*) displayed each a relative contribution of 34.7% of total individuals caught and third the blueshark (*Prionace glauca*) represented with 10.2% of catches (Tabl. 5).

Table 5 – List of species and specific abundance (N and %) in the capture

Scientific name	Common name	FAO Code	N	%
Makaira nigricans	Blue marlin	**BUM**	1	2
Alepisaurus ferox	Longnose lancetfish	**ALX**	17	34.7
Coryphaena hippurus	Common dolphinfish	**DOL**	1	2
Carcharhinus longimanus	Oceanic whitetip	**OCS**	1	2
Gempylus serpens	Snake mackerel	**GES**	3	6.1
Lepidocybium flavobrunneum	Escolar	**LEC**	1	2
Prionace glauca	Blue shark	**BSH**	5	10.2
Thunnus alalunga	Albacore tuna	**ALB**	3	6.1
Xiphias gladius	Swordfish	**SWO**	17	34.7
		Total	**49**	**100**

The time of hooking responses while the fishing period inferred from hook timers data is displayed on the figure 13. The distribution of hooking responses showed that during our experiments interactions between the gear and the pelagic fish resources were maximal between 20:00 and mid-night with 60% of hooking responses. Meanwhile, related to this previous result we observed that ~60% of hooking responses occurred with hooks soaked less than 5 hours (Fig. 14).

The capture time distribution for the swordfish as target species displayed a time window of two hours, from 19:00 to 21:00, where 50% of individuals where caught. An other time period from 00:00 to 01:00 observed a significant swordfish capture of 20% (Fig. 15). It must be noted that after the four first hours of the fishing time, swordfish capture reached ~60% of the total catch of the species. The link between these two results could be used to defined better fishing strategies by selecting the fishing period when the availability of the resource is maximal.

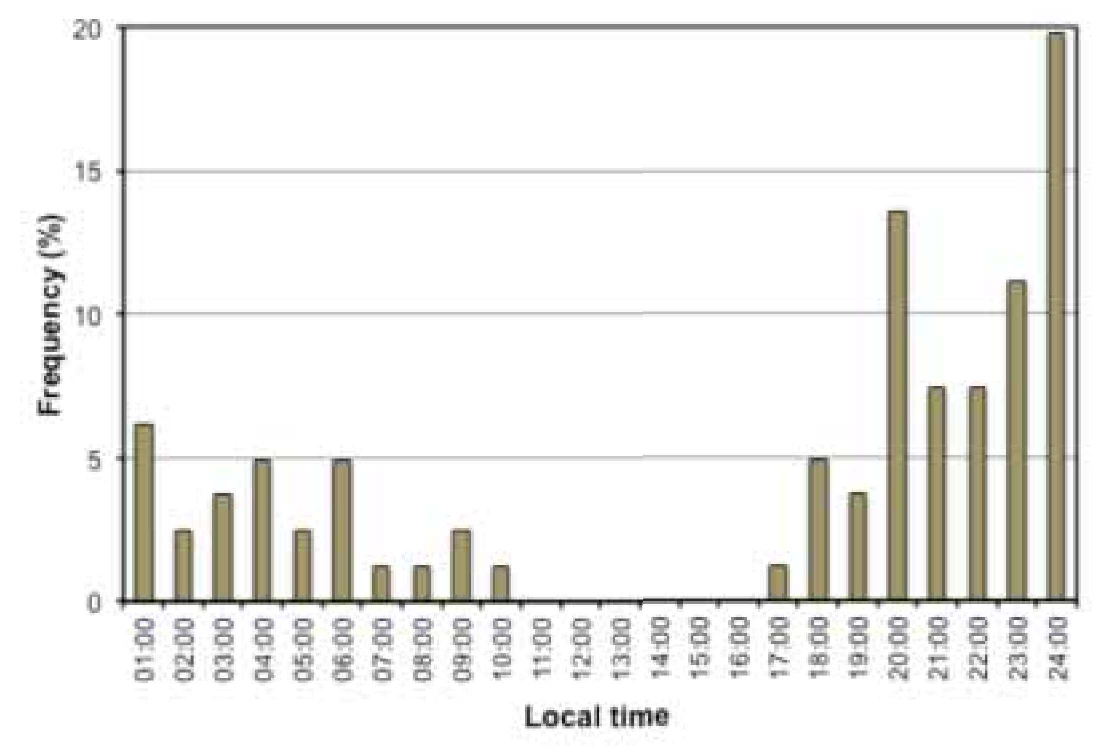


Figure 13 – Frequency (%) of hooking responses per hour during the time of the day (local time).

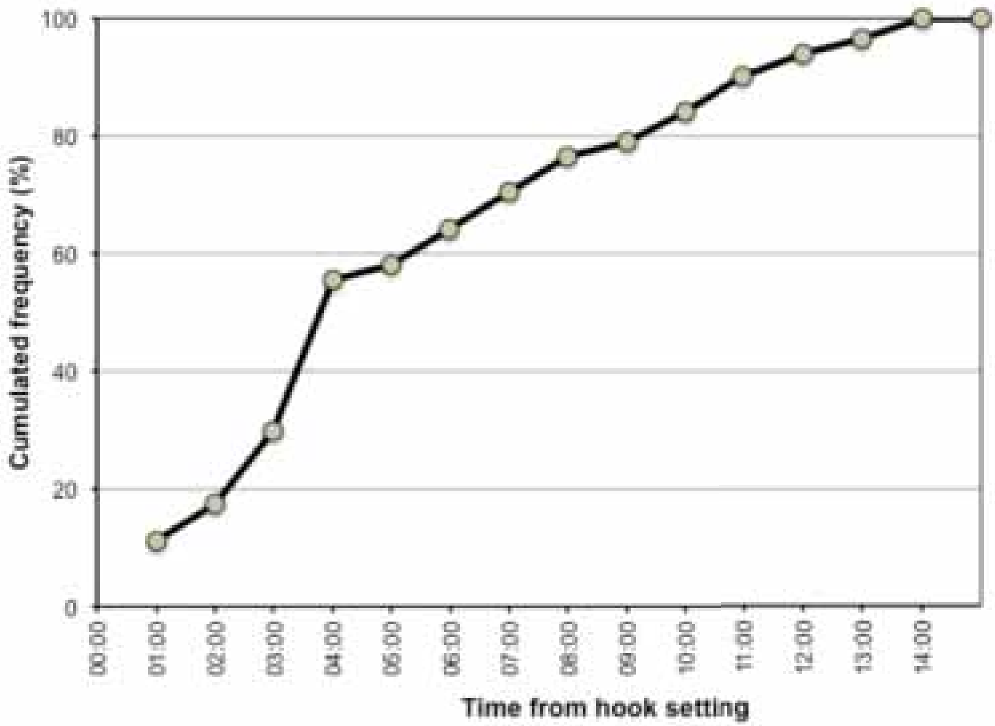


Figure 14 – Cumulated frequency (%) distribution of delay between the hook setting time and the hooking time for all hooking responses.

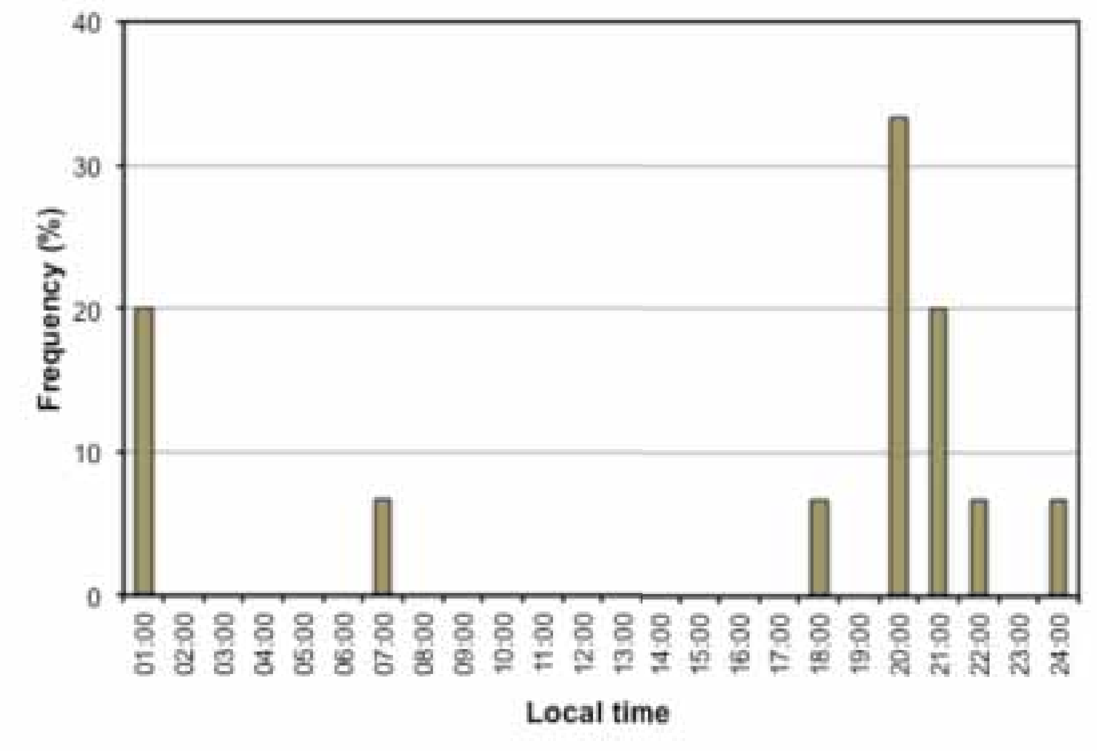


Figure 15 – Frequency (%) of hooking success per hour of swordfish during the time of the day (local time).

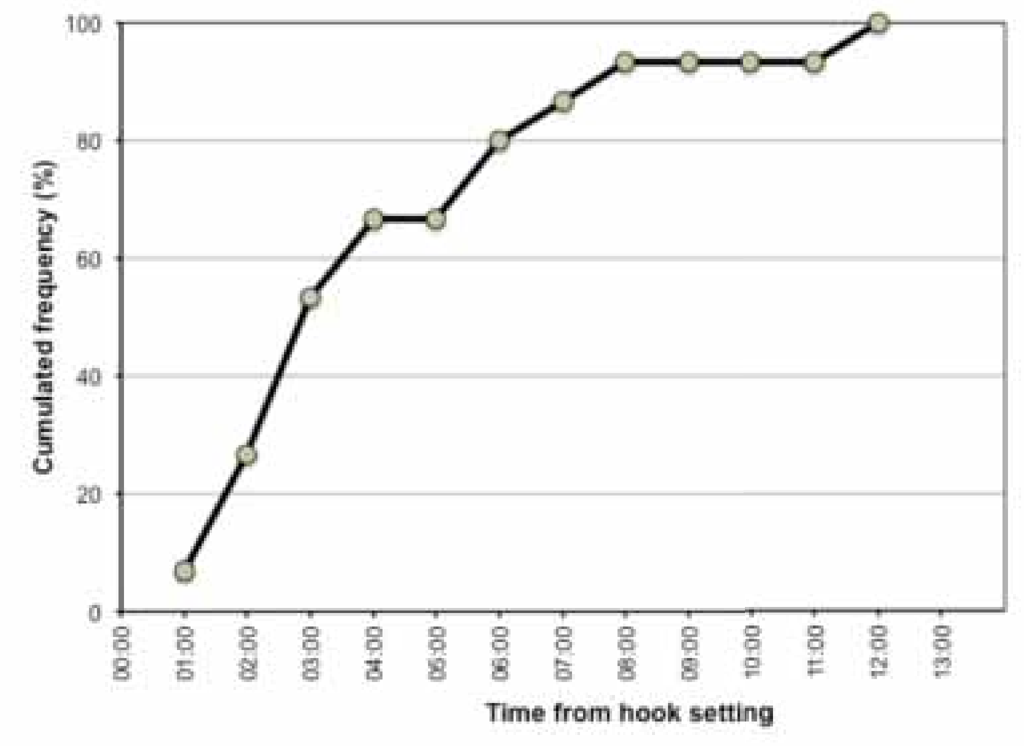


Figure 16 – Cumulated frequency (%) distribution of delay between the hook setting time and the hooking time of swordfish caught.

5 Conclusions

This SWIOFP Instrumented longline fishing cruise was a great opportunity for trainees of the SWIO region (Kenya, Tanzania, Mozambique, Comoros, Madagascar, Mauritius and Seychelles). They got a better appreciation of what is the work on field en general and what is the organization of a scientific cruise: how to control the scientific material which will be used on board (fishing materials and fishing sampling forms, fishing instruments, material for biological samples, field guide for species identification, XBT probe and XBT launcher), how to work with fishermen and how to pilot instrumented longline fishing experiments.

Organized in two batches of trainees this cruise was dense. Each member of the two groups was confronted with all operations carried out on board: longline deployment with beeper, hook timer (HT) setting, temperature depth recorder (TDR) setting, data collection during the longline hauling (hooking responses, hooking success), TDR data downloading, species identification, sampling biological and biometrical data on fish individuals and XBT deployment.

Hope this experience will be useful for SWIOFP partners for carrying out new instrumented longline surveys to better understand interactions between the fishing gear and the pelagic resources, the target species (swordfish and tunas) as well as all bycatch species with a particular attention on shark species and endangered species such as marine turtles.