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Project PESCARUN – preliminary results of swordfish studies in Reunion Island including experimental fishing, electronic tagging and trophic ecology

by

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ABSTRACT

A swordfish, *Xiphias gladius*, behaviour, movements, biology and trophic ecology was studied off Reunion Island (southwestern Indian Ocean) within framework of EU-funded project PESCARUN. The project includes experimental fishing with buoy fishing gear, stomach content analysis and tagging with a pop-up satellite electronic tag (PSATs). Here we present preliminary results of the project including tagging of 5 individuals, results of night fishing trials and stomach content analysis performed to date.

1. Introduction

Swordfish (*Xiphias gladius*) is an important commercial target species in the Indian Ocean for many local fishing fleets (France: Reunion and Mayotte Islands, Seychelles, Indonesia, Sri Lanka, India) and distant-water fleets (Spain, Portugal, and Taiwan) (IOTC, 2015). While the hypothesis of a single stock of swordfish in the Indian Ocean area was validated (Muths *et al.*, 2015), the population connectivity, migratory behaviour and mixing level over the area are still poorly known for this species.

Conventional “spaghetti” tagging programs in the western equatorial Indian Ocean (ABF, 2010) and the eastern Indian Ocean (Stanley, 2006) suggest active migratory behaviour associated with long-distance movements for *X. gladius* (Fig. 1). However, inherited limitations of conventional tagging do not permit to evaluate potential migratory patterns, swordfish behaviour and habitat in the region. Most of Indian Ocean electronic tagging experiments either fails (Poisson, Taquet, 2001) or demonstrated relatively limited displacements associated with highly productive zone of the southwestern Indian Ocean and Mozambique Channel (West et al., 2012). These experiments collected very limited data on habitat and vertical behaviour either due to early mortality of fish or poor performance of electronic tags.

Other attempts of electronic tagging were performed by IRD in 2012 (3 swordfish were tagged, one survived) and by CAP RUN – CITEB in 2015 one fish tagged and survived (Romanov et al., 2016). Both tagging experiments resulted in one successful long-term tracking each showed rather opposite movement patterns (Fig. 2).

Here we present a preliminary results of swordfish studies performed within framework of the Project PESCARUN including buoy fishing experiments, electronic tagging and trophic ecology.

2. Material and methods

Project PESCARUN is a continuation of the PELICAN project (2015-2016) that have been focused on swordfish buoy fishing and electronic tagging with overall limited success. New project expands project scope over trophic ecology studies and also envisaged utilisation of horizontal drifting longline gear for swordfish tagging in case of limited success of buoy fishing.

2.1. Fishing

Experimental fishing was performed using a Florida-style swordfish buoy gear (SBG) (Romanov et al., 2013). Up to 9 vertical lines were deployed at the surface off 5-10 miles off Reunion Island after sunset, then permanently monitored on potential predator attack using GPS buoys M2P (Marine Instruments S.A.[1]) (15 min reporting interval), AIS sensors and visually. As soon as potential fish bite was detected (change of fishing gear drift trajectory), fishing vessel immediately approached to SBG in attempt to retrieve fish as soon as possible trying to keep swordfish in good condition for further tagging. The fishing trials are carrying out since September 2021 in the northwest (off Port) and the north of Reunion Island (off Sainte Marie). The targeted fishing zone lies between 700 m and 1000 m depth. The longlines consisted of a 60 m, 100 m, 140 m and 150 m long mother line made of 2.5 mm transparent monofilament nylon and a 15 m leader made of 2.0 mm transparent monofilament nylon. 2 leaders per line were tested but this set-up was abandoned due to the difficulty of handling and the lack of success. 3 types of hooks are used: J-hook 16/0 in size, Circle 16/0 and 20/0. Maximum fishing depth was measured directly on all the lines using a Star-Oddi TDR (temperature-depth recorders). The observed maximum depth has not varied whether the line is weighted or not, therefore it was decided not to weight the lines in order to facilitate the handling. The lines are equipped either with yellow light-stick or blue, white, green or multi-coloured electralume (Lindgren-Pitman) lights. The baits used are mainly squid. Big-eye scad and skipjack tuna have also been used in few trials. All the lines are equipped with hook timer in order to know the time of capture or hooking contact. All the different types of set-ups were tested randomly. Vertical fishing lines were retrieved for checking of catch or bait status whenever the drift track appears to be out of a normal current drift track or every 2-3 h.

Two dedicated tagging cruises using horizontal drifting longline were performed: first onboard commercial fishing vessel ‘Le Bigouden’ and second one onboard fishery surveillance vessel ‘OSIRIS II’. To increase chance to catch swordfish in good condition and therefore probability of its survival a specific fishing technique with short longline gear (306 hooks deployed on average, range of 200-340) was used. Very short drifting (period between end of setting and start of

[1] http://www.marineinstruments.es Rúa dos Padróns nº 4 (Vial 3), Parque Empresarial Porto do Molle, 36350 Nigrán, Pontevedra, Spain.

hauling, average 3.0 hours, range 2.2-3.3) and soaking time (average 7.0 hours, range 4.7-7.7) was also applied. Branch lines of 26 m length were equipped with circle hooks (16/0 and 18/0 size) in order to reduce potential hooking injury. Hooks were baited with Northern shortfin squid (*Illex illecebrosus*), Argentine shortfin squid (*Illex argentinus*) or chub mackerel (*Scomber japonicus*). Squid and fish were used in equal proportions, except the first set, entirely squid-baited. The longlines were deployed in the surface layer before dusk (single set was set at midnight without any catch). A total of 14 fishing operations were realised over 13 days spent at sea.

2.2. Tagging

A MiniPAT electronic tag developed by Wildlife Computers Inc.[2] was used in our tagging experiments. It was programmed to record depth, temperature and light for a 100-days period. Time series for depth (5-min interval for 100 days deployments) was programmed to be always transmitted by satellite, as well as light levels recorded during twilight periods (used for geolocation) and profiles of depth and temperature (PDT; 4-hour interval) (Wildlife Computers, 2016). The tag was rigged with a Domeier (umbrella-type) plastic anchor (Domeier et al., 2005) provided by Wildlife Computers Inc. that attached with a stainless-steel tether. The MiniPAT has onboard tag emergency release mechanism (TERM) that releases the tag if the fish reaches a tag crushing depth of 1800 m (Wildlife Computers, 2016). The tag was also pre-programed to release from fish in case of 3 days inactivity, i.e. quasi-constant depth range (± 2.5m) assuming such inactivity corresponds to mortality of tagged fish: dead fish either fell to the sea bottom shallower than tag crushing depth or float at the surface. The inactivity clause also triggers data transmission process in case of fish mortality or tag premature detachment.

Swordfish caught with buoy gear or using horizontal drifting longline was tagged in water using tagging pole armed with an applicator provided by tag manufacturer. Only healthy, jaw-hooked or rostrum-hooked swordfish without bleeding and obvious injuries were tagged.

During SBG fishing a total of 2 swordfish were caught, both meet tagging requirements. During horizontal longline fishing a total of 12 swordfish were caught but only 5 individuals were tagged. The tag was anchored under the first dorsal fin.

[2] http://wildlifecomputers.com Wildlife Computers 8345 154th Avenue NE, Redmond, WA 98052, USA

The hook was removed from one fish caught with buoys, for the rest the monofilament leader of the fishing gear was cut at maximum proximity to the hook at time of fish release.

2.3. Stomach collection and analysis

Stomach of swordfish were routinely collected by scientific observers during commercial fishing operations, by scientists during tagging cruises and some were also taken at the fish processing factory in Reunion Island. A total of 82 stomachs were collected from 2017 to 2022. Stomach processing and analysis followed routine procedure described in Potier et al. (2007) and Romanov et al. (2020). Abundance of prey is expressed here in mean numeric percentage (MN%) and percentage of occurrence (%O), see Romanov et al. (2020) for details.

3. Results

3.1. SBG fishing

A total of 11 fishing trials have been made so far, 1 during the day from 13:00 to 21:00 pm and 10 during the night from 17:00 to 06:00. A total of 73 lines for a total of 75 hooks were deployed. Two swordfish were caught alive and were tagged and released. Another one large fish (likely swordfish, basing on marks on the line left by the rostrum) escaped by broking the line. One yellowfin tuna caught was depredated probably by an odontocete. One blue shark and one shortfin mako shark were caught and released alive in good condition. Some shark bite-offs were also recorded (assumed based on tooth marks on the line). The hook timer data also indicated five hooking contacts without catch. In these cases, the lines were not cut and no specifics marks allowed the identification of the catches. There is a possibility that these hooking contacts were due to squid depredation on the bait. Indeed, a lot of squid depredation was observed whenever the lines were lifted. At the current stage of fishing trials, a total CPUE is 66.6 ind / 1000 hooks, i.e.: for swordfish, a CPUE of 26.7 ind / 1000 hooks with 100% of individuals caught alive; for yellowfin tuna, a CPUE of 13.3 ind / 1000 hooks; for sharks, a CPUE of 26.7 ind / 1000 hooks with 100% of individuals caught and released alive.

3.2. Tagging performance

SBG. The first swordfish (estimated LJFL 120 cm) was tagged on 17/09/2021 (Table 1). Unfortunately, due to a handling error, it was released with most of the leader and the equipment attached to it: TDR and electralume. The individual died 2 days later probably of exhaustion (Fig. 3). The tag was released by TERM and emitted data during ~17 days. During two days of tracking fish mowed in northern direction covering an approximate distance of 28 nautical miles (nmi). The second swordfish (est. LJFL 100 cm) was tagged on 18/01/2022. The mark popped up in close proximity to Reunion Island on 05.04.2022, i.e. remained ~79 days in the water. It emitted its data during ~21 days. A data analysis in few days after tag popped-up, shows absence of light data for a whole tracking period except day of tagging and period after tag have been surfaced. Together with vertical migration pattern unusual for swordfish (daytime depth occupation between 600 and 1200 m and nigh-time depth range 350-130 m) data suggests that the tagged swordfish was eaten by a meso- or benthopelagic shark, most likely a sixgill shark *Grampus griseus*, which finally regurgitated foreign object from the stomach.

Longline. Five swordfish of LJFL ranged from 120 to 170 cm were tagged south from Reunion Island within EEZ during the cruise onboard F/V Bigouden from 27.07 to 03.08.2022 (Table 1). To date all tags except one are not emitting that suggest no mortality. The only popped up tags shows no mortality also. It was detached from fish after 8 days of tracking apparently due to attachment failure. Tag emitted for ~20 days. Fish demonstrated a local semi-circular movement in north then west direction covering an approximate distance of 269 nmi.

More detailed analysis including horizontal movements, vertical behaviour and habitat will be presented after termination of the project during next WPB.

3.3. Stomach content analysis

A total of 51 swordfish stomach were processed to date from fish ranged from 59 to 236 cm LJFL (mean 136.8±41.6) (Fig. 3). 37 stomach (72.5%) were non-empty. Principal prey of swordfish analysed to date was Indian ocean neon flying squid *Ommastrephes cylindraceus* (12.6% in MN% and 24.3% in %O), purpleback flying squid *Sthenoteuthis oualaniensis* (12.0% in MN% and 24.3% in %O), Parin's spinyfish *Diretmichthys parini* (9.8% in MN% and 18.9% in %O), whale squids *Walvisteuthis* spp. (4.1% in MN% and 5.4% in %O), and prickly fanfish *Pterycombus petersii* (3.2% in MN% and 8.1% in %O).

4. Discussion

While swordfish CPUE of SBG fishing operations seems to be relatively high, compare with horizontal longline CPUE (26.7 ind / 1000 hooks vs <20 ind / 1000 hooks in usual commercial fishing operations) the overall capture of less than one swordfish per fishing trip seems to be non profitable from the economic point of view. Fish caught with SBG is usually in good condition for tagging, however poor fishing success makes difficult to reach tagging objectives during project duration.

Tagging operations using short horizontal longline equipped with long branchlines (26 m) associated with short soaking time apparently allows to catch and release swordfish in good conditions with high probability of post-release survival. Since most of tag are still attached to a fish, detailed results will be presented at the next WPB.

In the waters of Reunion Island and southern part of Mozambique Channel swordfish mostly preying on squids and mesopelagic fishes. Detailed diet analysis, including prey length and consumed biomass will be presented at the next WPB.

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http://wildlifecomputers.com/wp-content/uploads/manuals/MiniPAT-User-Guide.pdf

Table 1 Summary of tagging information for swordfish

PTT	Serial number	Species	LJFL (cm) estimated	Programmed period (days)	Anchor	Tagging: Date	Tagging: Lat	Tagging: Long	Pop-up: Date: first transmission / surfacing	Pop-up: Lat (first transmission)	Pop-up: Lon (first transmission)	Fish fate	Days at liberty: first transmission / surfacing	Direct distance travelled / distance per day (nmi)
153475	15P0292	SWO	230	90	Domeier	17.12.2015	21°10’S	55°05’E	27.02.2016 / 24.02.2016	01°30'S	60°37'E	Survival	72 / 69	1224.5 / 17.7
203180	20P0752	SWO	120	100	Domeier	17.09.2021	20°52’S	55°13’S	18.09.2021	20°52’S	55°13’E	Mortality, fish handling error	2	28 / 14
203178	20P0700	SWO	100	100	Domeier	18.01.2022	20°49’S	55°33’S	05.04.2022	20°49’E	55°33’E	Mortality, shark predation	0	
203181	20P0787	SWO	120	100	Domeier	27.07.2022	23°15’S	54°22’E				In water		
203179	20P0701	SWO	160	100	Domeier	28.07.2022	23°24’S	54°58’E				In water		
203183	20P0789	SWO	120	100	Domeier	30.07.2022	23°13’S	55°21’E	07.08.2022	18°31’S	55°56’E	Premature, attachment failure	8	269.0 / 33.6
203185	20P0792	SWO	120	100	Domeier	31.07.2022	23°14’S	55°30’E				In water		
203184	20P0790	SWO	160	100	Domeier	03.08.2022	21°44’S	54°53’E				In water		

LJFL: lower jaw – fork length, Distance: straight distance between tagging and pop-up locations

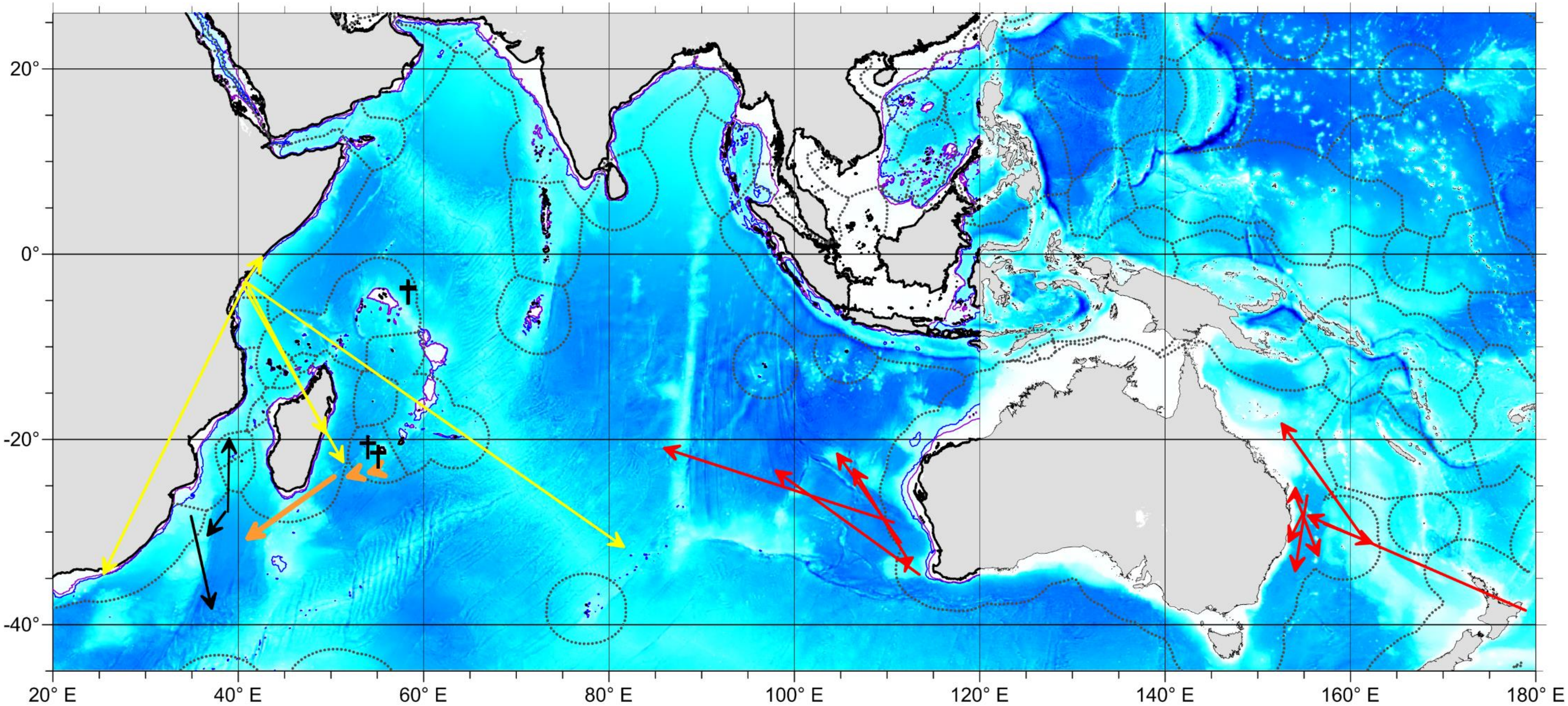

Figure 1. Past swordfish tagging experiments in the Indian Ocean and adjacent areas of the Pacific. Conventional tagging: red arrows are from Stanley (2006), yellow arrows are from ABF (2010). PSAT tagging (direct direct distance travelled): black crosses (100% SWO mortality) are from Poisson, Taquet (2001), black arrows are West et al. (2012), and orange arrows are IRD SWIOFP Project tags (Marsac, 2013 pers. comm.).

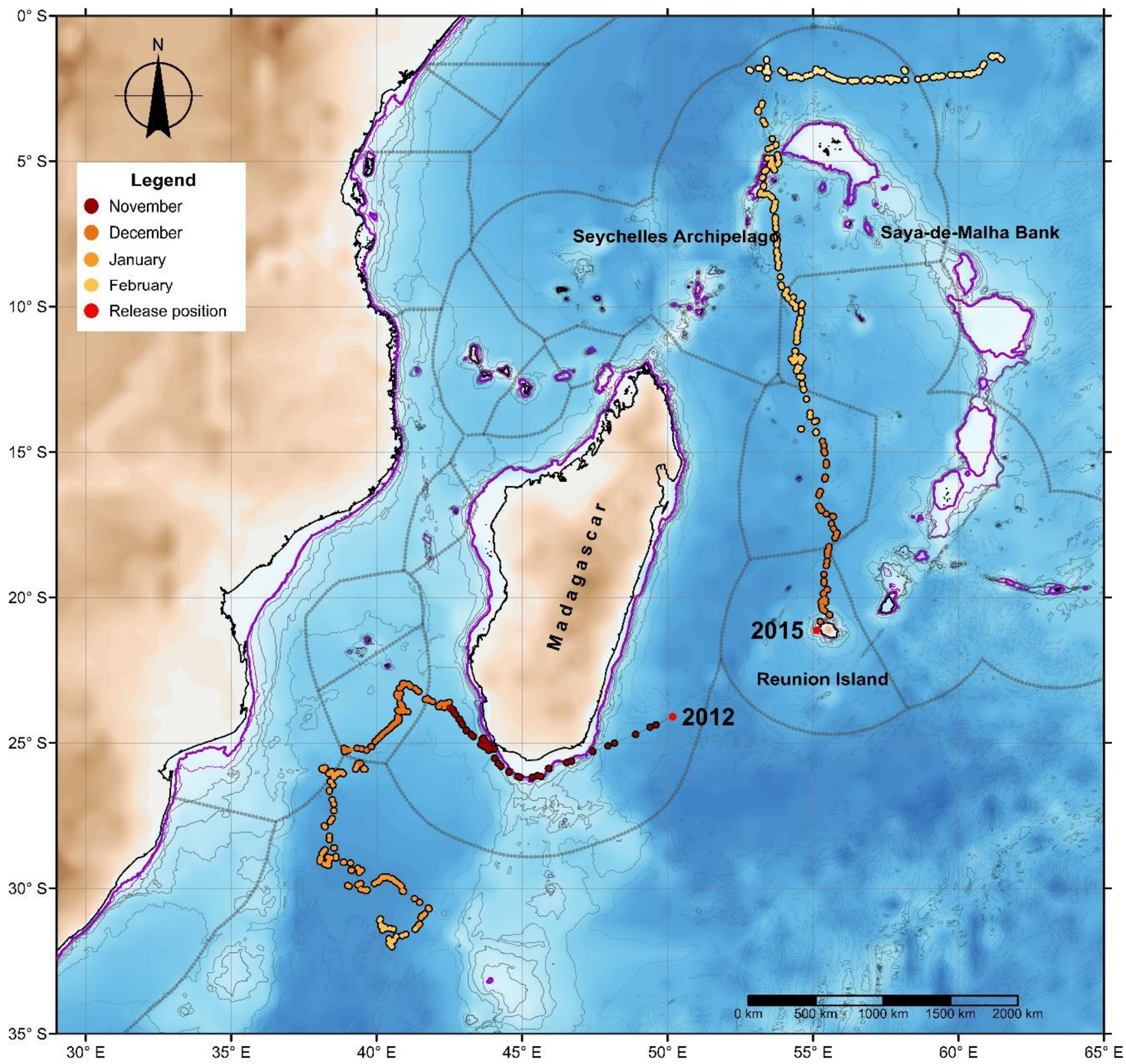

Figure 2. Most likelihood tracks for swordfishes tagged by IRD (2012) and by CAP RUN – CITEB (2015). Approximate position of the 200-mile Exclusive Economic Zones (EEZs) of costal states (grey dotted line), the 200 m isobath (purple line) and bathymetry from 1000 to 5000 m (in 1000 m steps, light lines) are shown. Coastline and bathymetry data are from GEBCO (GEBCO, 2010), EEZs are from VLIZ (2014).

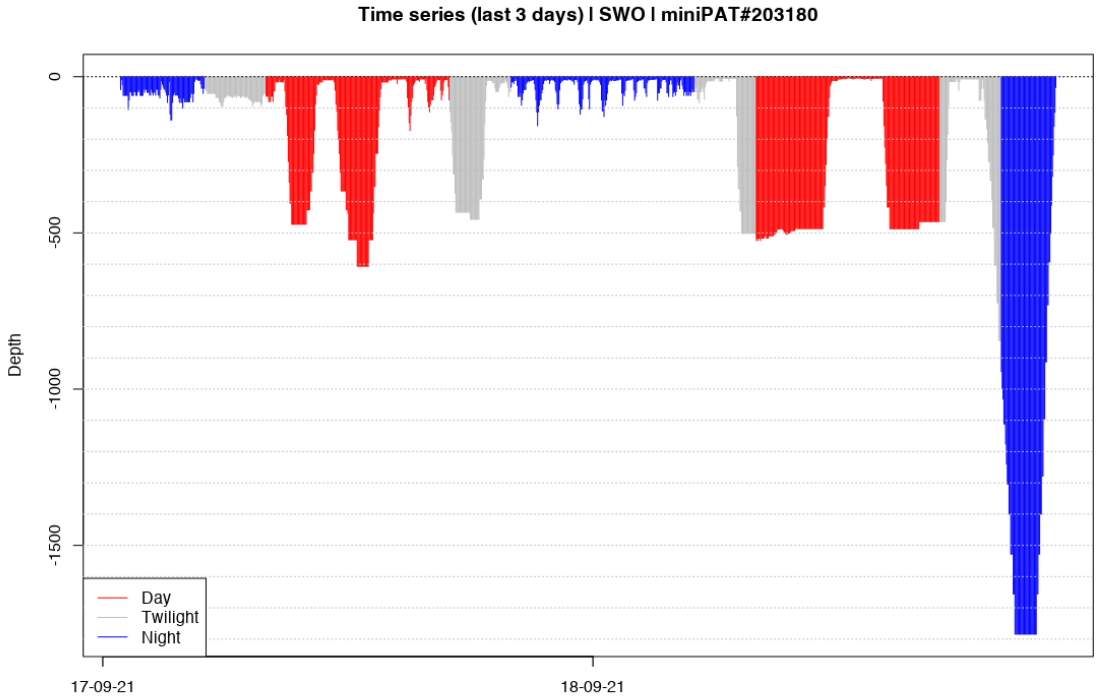

Figure 3. Depth time series for tag swordfish #203180 shown mortality two days after tagging. Blue, red, grey bars receptively correspond to night, day and twilight observations

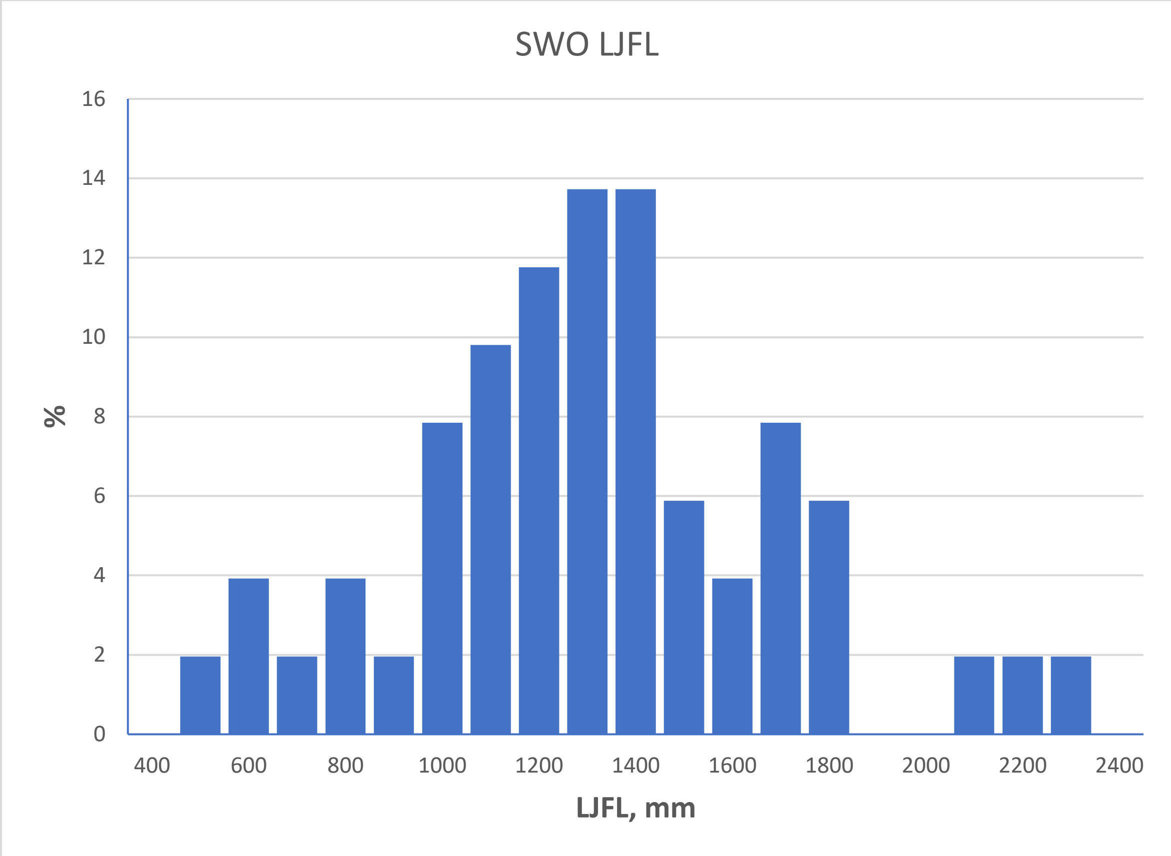

Figure 4. Length frequency of swordfish analysed for stomach contents.