

BRIEF UPDATE ON THE SATELLITE TAGGING OF ATLANTIC SWORDFISH

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SUMMARY

This paper provides a brief update of the study on habitat use for swordfish, developed within the working plan of the Swordfish Species Group of ICCAT. A total of 9 miniPAT tags have been deployed by observers on Portuguese and Spanish vessels and the Uruguayan research cruise in the North and South Atlantic. Data from eight tags/specimens are available, four specimens suffered from post-release mortality and one individual tag pop-up date has not occurred yet. These preliminary results showed swordfish moved in several directions, travelling considerable distances. Swordfish spent most of the daytime in deeper waters, being closer to the surface during night-time. The main plan for the next phase of the project is to continue the tag deployment during 2020 in several regions of the Atlantic Ocean and Mediterranean Sea.

RÉSUMÉ

Ce document fournit une brève mise à jour de l'étude sur l'utilisation de l'habitat par l'espadon, développée dans le cadre du plan de travail du Groupe d'espèces sur l'espadon de l'ICCAT. Au total, 9 marques miniPAT ont été déployées par des observateurs sur des navires portugais et espagnols et lors d'une campagne de recherche uruguayenne dans l'Atlantique Nord et Sud. Les données de huit marques/spécimens sont disponibles, quatre spécimens ont souffert de mortalité post-remise à l'eau et le détachement d'une marque individuelle n'a pas encore eu lieu. Ces résultats préliminaires ont montré que l'espadon se déplaçait dans plusieurs directions, parcourant des distances considérables. L'espadon passait la plupart de la journée dans des eaux plus profondes, étant plus proche de la surface pendant la nuit. L'objectif principal de la prochaine phase du projet est de poursuivre le déploiement des marques en 2020 dans plusieurs régions de l'océan Atlantique et de la mer Méditerranée.

RESUMEN

Este documento proporciona una breve actualización del estudio del uso del hábitat del pez espada, desarrollado en el marco del plan de trabajo del Grupo de especies de pez espada de ICCAT. Los observadores han desplegado un total de 9 marcas miniPAT en buques portugueses y españoles y en el crucero de investigación uruguayo en el Atlántico norte y sur. Se dispone de datos de ocho marcas/ejemplares, cuatro ejemplares sufrieron mortalidad posterior a la liberación y todavía no se ha producido el desprendimiento de una marca pop-up. Estos resultados preliminares mostraron que el pez espada se movía en varias direcciones, viajando distancias considerables. El pez espada pasó la mayor parte del día en aguas más profundas, y permanecía más cerca de la superficie durante la noche. El plan principal para la próxima fase del proyecto es continuar el despliegue de la marca durante el año 2020 en varias regiones del océano Atlántico y el mar Mediterráneo.

KEYWORDS

Satellite tagging; Xiphias gladius; habitat use; movement patterns; Atlantic; Mediterranean.

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1. Background

Swordfish (*Xiphias gladius*) is an epi-and mesopelagic oceanic species with a wide geographical range within tropical and temperate waters of all oceans (Nakamura, 1985). Globally, it is one of the most important target species for domestic coastal and distant water longline fleets (Ward *et al.*, 2002).

Even though it is one of the most important species for longline fleets, there are still important knowledge gaps regarding the biology, distribution and habitat of swordfish that affect the assessments and management options. In ICCAT (International Commission for the Conservation of Atlantic Tunas), the Standing Committee on Research and Statistics (SCRS) has requested the revision of life history parameters, such as age and growth, the implementation of a tagging program for improved information on movements, habitat preferences and stock delimitation, and a detailed study on size and sex distribution of swordfish (ICCAT, 2017).

In 2018, the Swordfish Species Group initiated a collaborative tagging program to study the habitat use and migration patterns of swordfish, and to help delimitate the stock boundaries and mixing rate of swordfish between the Mediterranean Sea, North and South Atlantic. This working document presents a brief update on the satellite tagging work so far.

2. Methods

2.1 Tag acquisition

MiniPAT tags built by Wildlife Computers (WC) were used in this study. The first tags acquisition process was conducted during 2018, 15 tags were acquired and distributed by the collaborators. Additionally, 14 tags were acquired during 2019. **Table 1** describes the numbers of tags acquired during the two phases and their allocation for deployment as well as the current deployment status. A tag from 2017 was also available and is included in this study. So far, 9 tags were deployed in the Atlantic Ocean. The remaining tags were sent back to the manufacturer due to identified battery issues in a batch of tags.

2.2 Tagging procedure

Tagging took place across a wide area of the Atlantic Ocean during 2017 to 2019 and was conducted in the Portuguese and Spanish pelagic longline fleet and the Uruguayan research vessel (**Figure 1**). The tag deployment was opportunistic when swordfish were captured during the regular fishing operations. Swordfish were either hoisted alongside the vessel or brought on board for tagging. An umbrella-type nylon dart was used to insert the tag laterally to the dorsal musculature below the dorsal finbase. Before tag attachment, tags were tested for accurate data collection, and were programmed to record information for periods of 180 days. In addition, the animals were measured for lower jaw fork length (LJFL). Date and time were recorded, and the geographic tagging location (latitude and longitude) was determined by Global Positioning System (GPS).

2.3 Data analysis

Geographic positions at tagging were determined by GPS, while the pop-up locations of transmitting tags were established as the first point of transmission with an Argos satellite. In order to investigate movement patterns, the most probable tracks between tagging and pop-up locations were calculated from miniPATs light level data using astronomical algorithms provided by the tag manufacturer. To improve the geolocation accuracy, a state-space model incorporating a sea surface temperature field was applied using the Wildlife Computers GPE3 software (Wildlife Computers, 2018). Vertical habitat use was investigated by summarizing the depth and temperature profiles of the tagged swordfish and analysing the depth and temperature profile plots. All statistical analyses for this paper were carried out with the R language (R Core Team, 2018). Plots were created using package “ggplot2” (Wickham, 2009).

3. Results and Discussion

Nine MiniPAT tags were deployed so far during this study (**Figure 1**). Of the deployed tags, four individuals suffered post-release mortality, three tags suffered from premature releases (popping up before the expected date), one tag reached the full term, and one individual tag pop-up date has not occurred yet (**Table 2**). Data from the eight tags was transmitted, however for the tags with more tracking days, the transmitted data has many gaps in depth and temperature, sometimes of several days, meaning it did not transmit the full collected data. These tags seem to have suffered from the same battery issues that have been identified by the manufacturer for other undeployed tags, and that were only communicated to the authors after the deployments were done.

Of the three swordfish tagged in the North Atlantic that did not suffer from post-release mortality, two individuals moved north, and one individual moved south (**Figure 1**). The distances travelled ranged from 110 km for the individual with 3 tracking days to 6825 km for the individual for which the tag popped up on the programmed date (180 tracking days) (**Table 1**).

Swordfish swam through a depth range from the surface down to 786 m, with mean depth of 310.6 m. Water temperatures ranged between 8.7 and 31.8 °C, with mean temperature of 17.3 °C. Swordfish spent most of the night-time in depths above 100 m and preferred a range of water temperatures from 20 to 26 °C. During daytime swordfish preferred deeper depths, below 500 m and reaching almost 800 m, and temperatures of 10 to 12°C (**Figures 2-5**). Swordfish follow a daily vertical migration pattern, being in the surface during the night-time and diving to deeper waters during the daytime (**Figure 2**). One of the swordfish spent most time at depths between 0 and 50 m with occasional deeper dives, but never deeper than 350 m (**Figure 3**). As discussed above, the longer the deployment, the less data was transmitted by the tag, as can be seen by the data gaps in depth and temperature of individuals with tag 179709 and 179711 (**Figure 4-5**).

The tagging program will continue during 2020 with the deployment of tags to be acquired during this year, and the tags replaced by the manufacturer due to the above identified issues in the areas of interest (North/South and Mediterranean/Atlantic stock boundaries).

4. Acknowledgments

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5. References

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Table 1. List with the distribution of miniPATs and sPATs by the participating Institutes, for the 2 project phases. Current deployment status and additional notes are also provided.

	Institute	Tag quantity	Deployment status
2017	DINARA (Uruguai)	1	Deployed
2018	IEO (Spain)	6	1 tag deployed; remaining to be returned to manufacturer
	IFREMER (France)	4	No tags deployed. All to be returned to manufacturer
	UNIGE (Italy)	4	No tags deployed. All to be returned to manufacturer
	IPMA (Portugal)	1	Deployed
2019	IPMA (Portugal)	14	6 tags deployed; remaining to be returned to manufacturer

Table 2. Information on deployed tags. All tags were programmed to pop-up after 180 days with the individual.

Tag ID	Deployment date	Size (LJFL, cm)	Fate	Tracking days	Distance travelled (km)	Comments
167200	05/06/2017	135	Mortality	3	110	
62423	15/03/2019	120	Mortality	0		
62603	26/03/2019	96	Alive	8	335	Premature release, although the track has few days does not look like it died
179708	29/05/2019	109	Alive	67	4354	Premature release
179709	08/06/2019	110	Alive	180	6825	Popped-up on the expected date, but transmitted data has many intervals
179710	13/06/2019	110	Mortality	0		
179711	08/06/2019	105	Alive	86	3778	Premature release
181044	27/10/2019	117	Unkown			In the water, expected pop-up date 24/04/2019
181046	15/06/2019	91	Mortality	0		

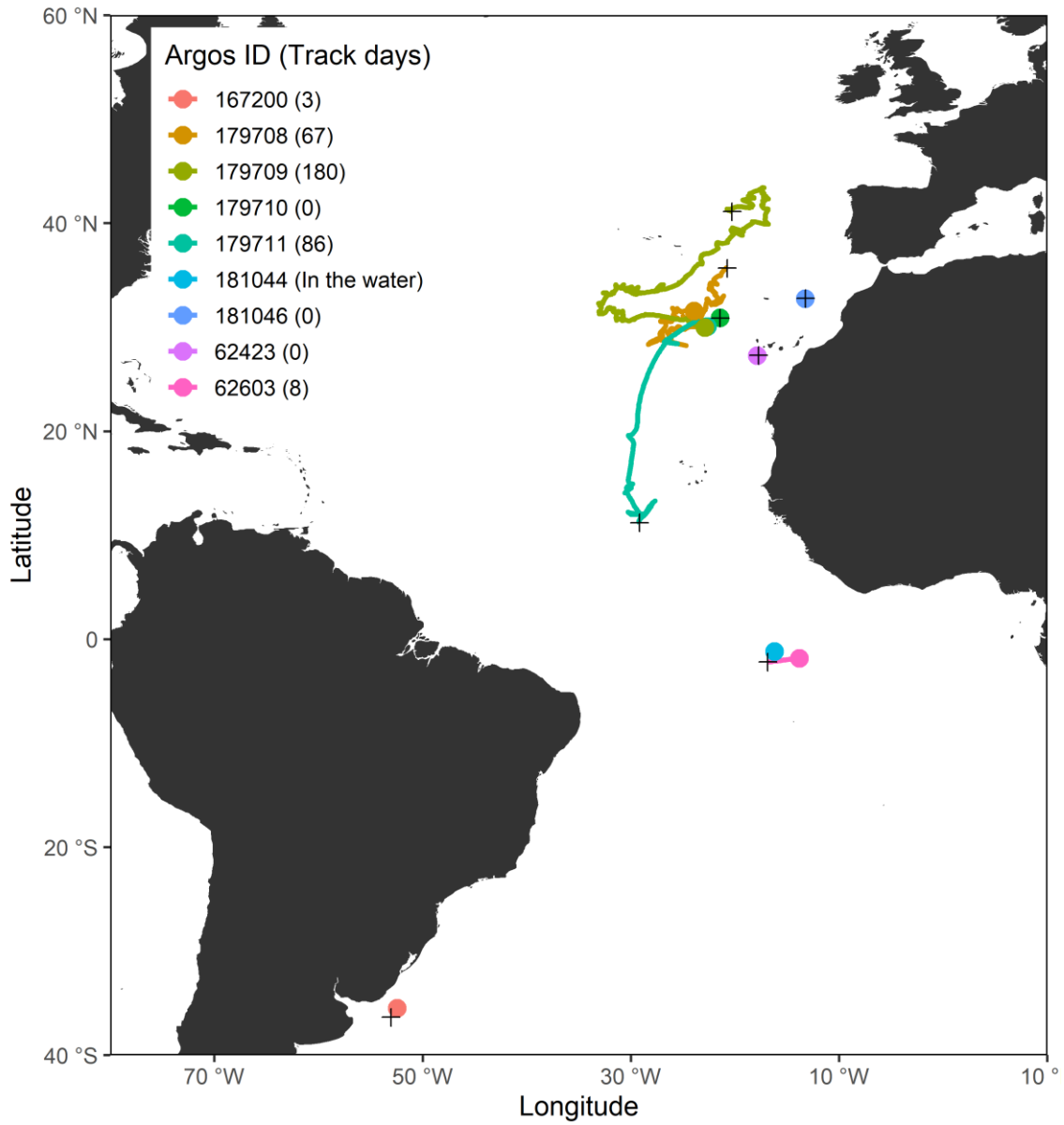


Figure 1. Map with the location of the swordfish (*Xiphias gladius*) tag deployments, and most likely tracks of four individuals that did not suffer from post-release mortality. The colored point identifies the tagging location and the colored lines the individual tracks, the black cross indicates the location of the pop-up.

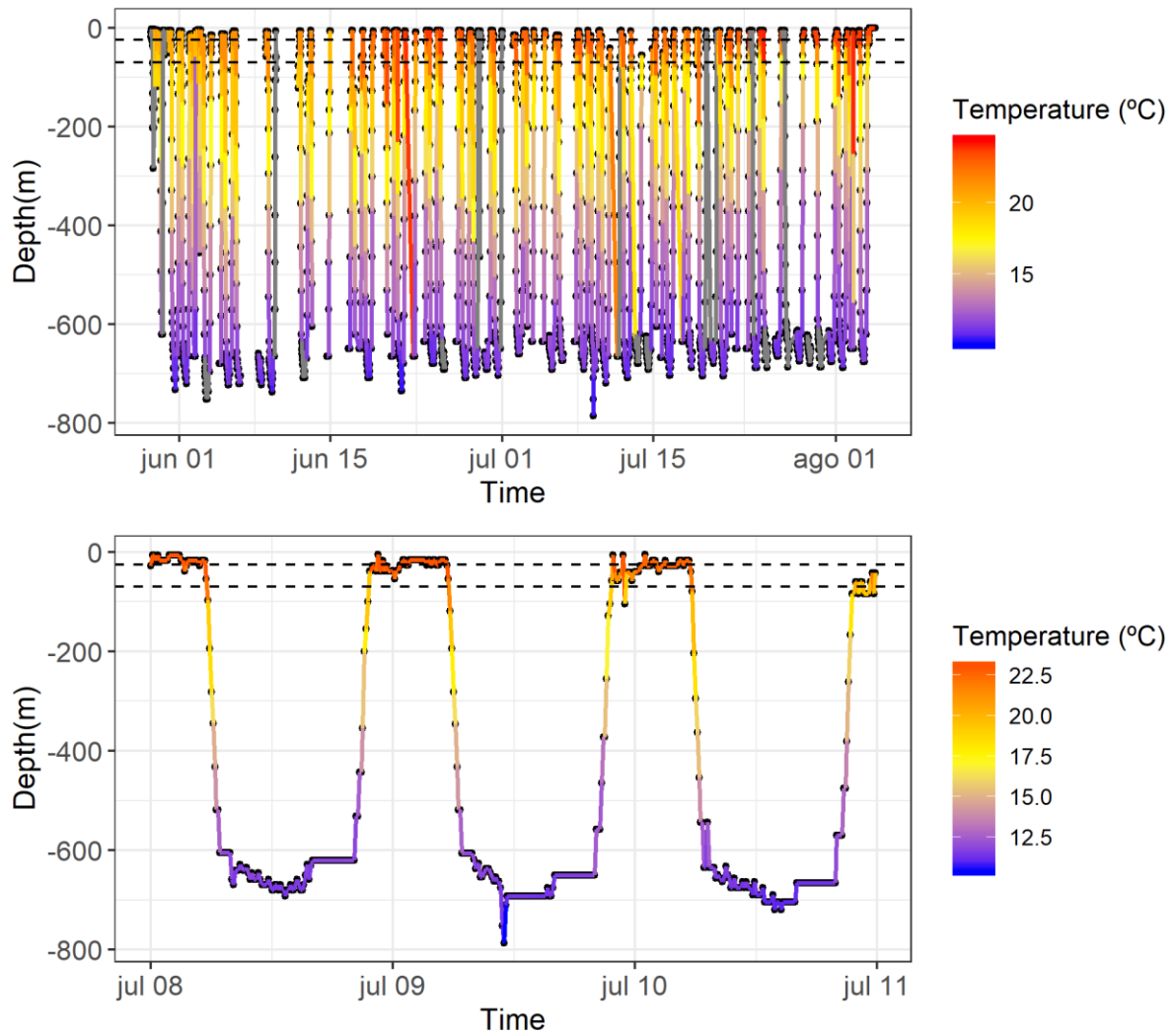


Figure 2. Depth and temperature profiles of an individual swordfish with 109 cm lower jaw fork length. Top panel represents 67 days tracking days; bottom panel represents a 3-day snapshot.

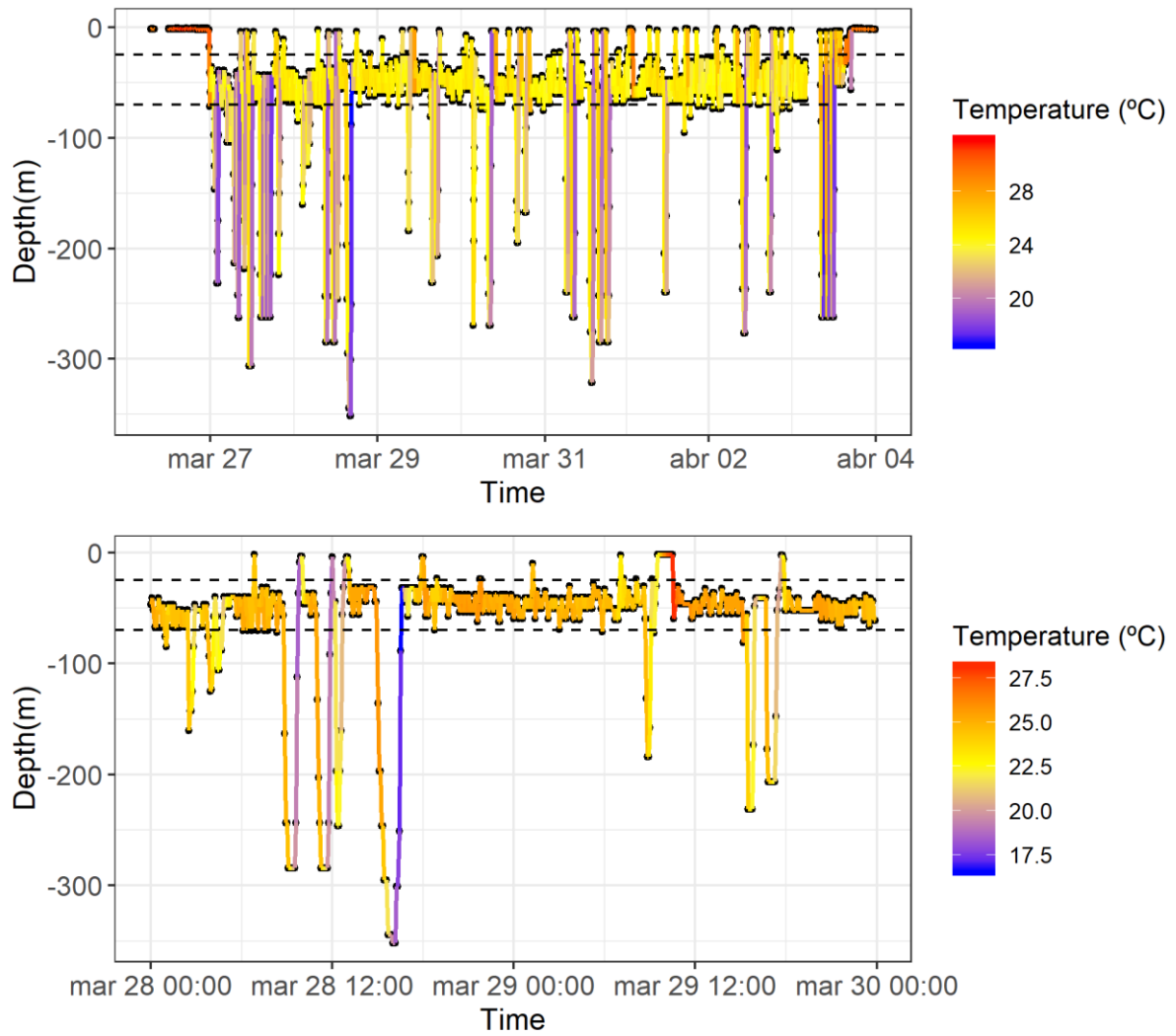


Figure 3. Depth and temperature profiles of an individual swordfish with 96 cm lower jaw fork length. Top panel represents 8 tracking days; bottom panel represents a 2-day snapshot.

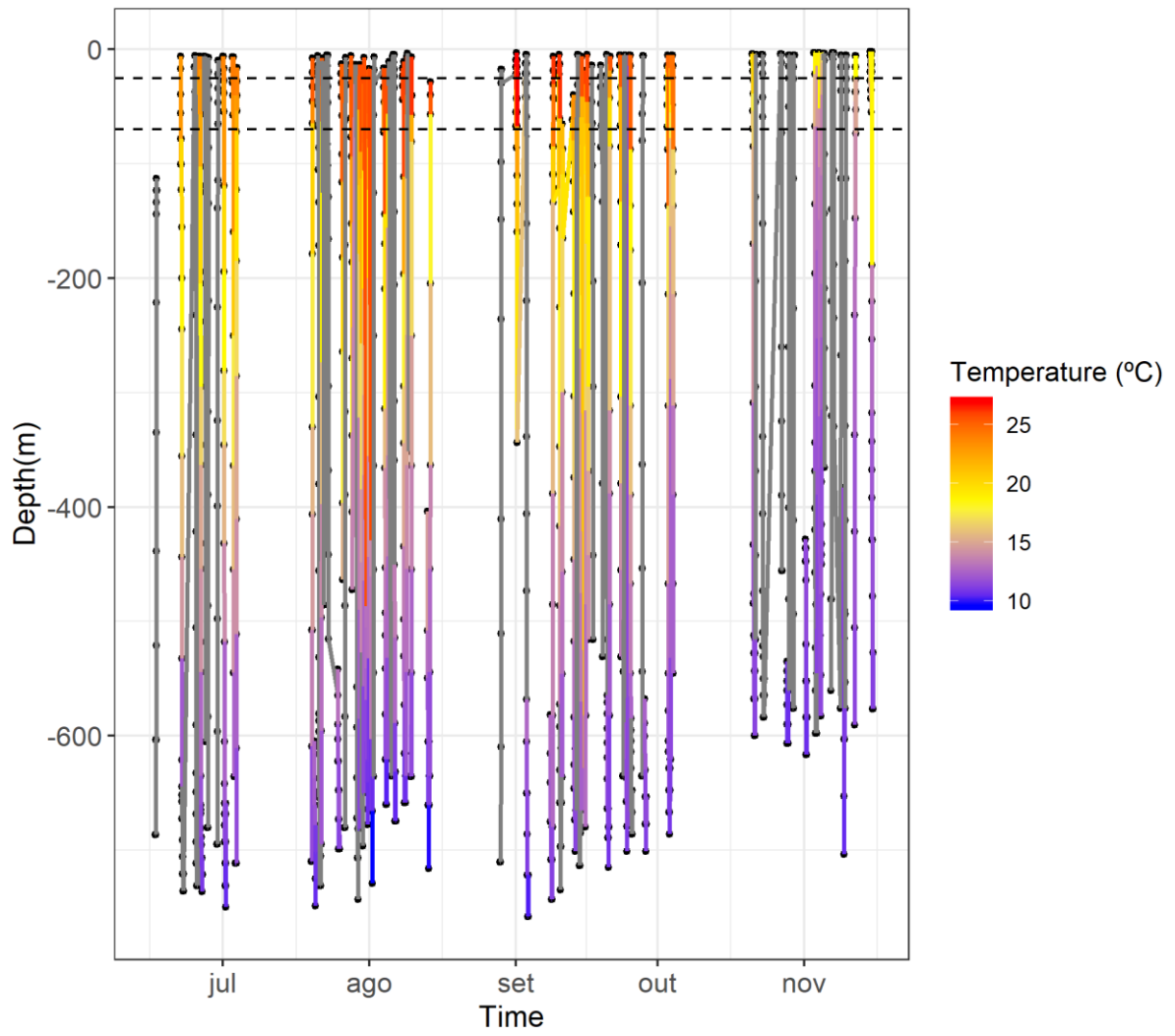


Figure 4. Depth and temperature profiles of an individual swordfish with 110 cm lower jaw fork length with 180 tracking days.

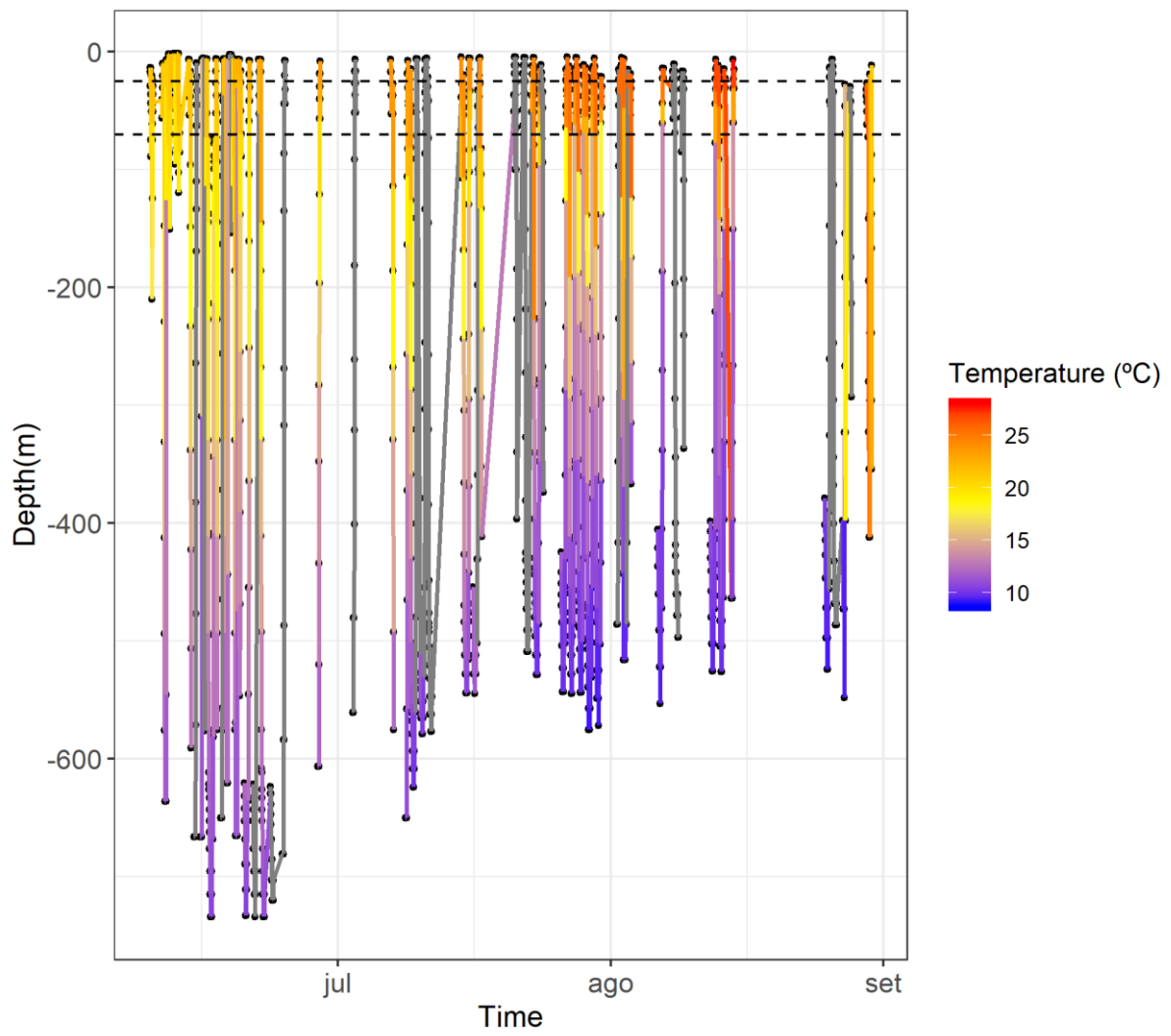


Figure 5. Depth and temperature profiles of an individual swordfish with 105 cm lower jaw fork length with 86 tracking days.