SCRS/2017/147 Collect. Vol. Sci. Pap. ICCAT, 74(7): 3671-3678 (2018)

UPDATE ON POST-RELEASE SURVIVAL OF TAGGED WHALE SHARK ENCIRCLED BY TUNA PURSE-SEINER

L. Escalle[1,2], J.M. Amandé[3], J.D. Filmalter[4],
F. Forget[2], D. Gaertner[2], L. Dagorn[2], B. Mérigot[5]

SUMMARY

In the tropical eastern Atlantic Ocean, whale sharks are sometimes encircled by nets of tropical tuna purse-seiners. In order to estimate the post-release survival of encircled individuals, a post release survival experiment, using pop-up satellite tags, was conducted in this ocean in 2014. This study presents updated results from this experiment. In addition to the six (five included in the study and an individual from Murua et al. 2014) whale sharks tagged in June–July 2014, five other individuals were tagged in June 2016. Among these 11 tags, seven individuals survived at least 21 days after release, three tags detached after 3 and 7 days and the fate of these individuals remains unknown, and one tag failed to report. Although the sample size remains limited, the results indicate a post release mortality rate following encirclement of large whale shark of 0%. Nevertheless, there remains an urgent need to increase post-release tagging experiments of whale shark encircled by purse-seine nets to estimate the survival rate and to define, if needed, regulatory measures to protect this shark species.

RÉSUMÉ

Dans l'océan Atlantique-est tropical, les requins-baleines sont parfois entourés de filets par les senneurs ciblant les thonidés tropicaux. Afin d'estimer la survie après la libération des spécimens encerclés, une expérience de survie post libération, à l'aide de marques pop-up reliées par satellite, a été menée dans cet océan en 2014. Cette étude présente les résultats mis à jour de cette expérience. En plus des six (cinq inclus dans l'étude et un spécimen de Murua et al., 2014) requins-baleines marqués en juin- juillet 2014, cinq autres spécimens ont été marqués en juin 2016. Sur ces 11 marques, sept spécimens ont survécu au moins 21 jours après leur libération, trois marques se sont détachées au bout de 3 à 7 jours et le sort de ces spécimens reste inconnu tandis qu'une marque n'a réalisé aucune transmission. Bien que la taille de l'échantillon reste limitée, les résultats indiquent un taux de mortalité post libération après l'encerclement des grands requins-baleines de 0%. Néanmoins, il reste un besoin urgent d'augmenter les expériences de marquage et de libération du requin-baleine entouré des filets de senne pour estimer le taux de survie et définir, le cas échéant, des mesures réglementaires destinées à protéger cette espèce de requin.

RESUMEN

En el océano Atlántico tropical oriental, los tiburones ballena a veces son cercados por las redes de los cerqueros atuneros tropicales. Para estimar la supervivencia posterior a la liberación de los ejemplares cercados, en 2014 se realizó un experimento de supervivencia posterior a la liberación utilizando marcas pop-up por satélite. Este estudio presenta una actualización de este experimento. Además de los seis (cinco incluidas en el estudio y un ejemplar de Murua et al. 2014) ejemplares de tiburones ballena marcados en junio-julio de 2014, en junio de 2016 se marcaron otros cinco ejemplares. De estos once ejemplares marcados, siete sobrevivieron al menos 21 días después de su liberación, tres marcas se despegaron después de 3 y 7 días, y el destino de dichos ejemplares se desconoce, y una marca

[1] Pacific Community (SPC), B.P. D5, 98848 Noumea, New Caledonia (laurianee@spc.int)
[2] Institut de Recherche pour le Développement (IRD), UMR MARBEC (IRD, Ifremer, Univ. Montpellier, CNRS), Av. Jean Monnet, CS 30171, 34203, Sète, France
(fabien.forget@ird.fr, daniel.gaertner@ird.fr, laurent.dagorn@ird.fr)
[3] Centre de Recherches Océanologiques (CRO), Département Ressources Aquatiques Vivantes, Abidjan, Côte d'Ivoire (monin.amande@cro-ci.org)
[4] South African Institute for Aquatic Biodiversity, Somerset Street, Grahamstown, 6139, South Africa (jdfilmalter@gmail.com)
[5] Université Montpellier, UMR MARBEC (IRD, Ifremer, Univ. Montpellier, CNRS), Av. Jean Monnet, CS 30171, 34203, Sète, France (bastien.merigot@umontpellier.fr)

no transmitió información. Aunque el tamaño de la muestra es limitado, los resultados indican que para los ejemplares grandes de tiburones ballena a tasa de mortalidad tras la liberación después de haber sido cercadas es del 0%. Sin embargo, sigue existiendo una urgente necesidad de incrementar los experimentos de marcado tras la liberación de tiburones ballena cercados por las redes de cerco con el fin de estimar la tasa de supervivencia y definir, si es necesario, las medidas regulatorias para proteger estas especies de tiburones.

KEYWORDS

*Whale sharks, Post-release survival, Satellite tracking,
Tropical tuna purse seine, Megafauna*

1 Introduction

Tropical tuna purse-seine vessels actively search for signs that indicate the presence of tuna schools at the surface (Ariz et al., 1999). As tuna are known to aggregate around floating objects (natural or artificial) and/or associate with megafauna species (*e.g.* whale shark (*Rhincodon typus*, Smith 1828); cetaceans) (Stretta and Slepoukha, 1986, Hall 1998, Ariz et al., 1999, Romanov, 2002, Matsunaga et al., 2003), they may be used to detect tuna schools. As a result, whale sharks are sometimes encircled in the nets of tropical tuna purse-seine vessels (Escalle, 2016). This is often an involuntarily outcome, as fishers may not notice the whale shark before setting their net on a school of tuna (Capietto et al., 2014), but can also sometimes be intentional, if the crew have sighted a whale shark with which a tuna school is associated.

Following concerns of the impact of tuna purse seine fisheries on whale shark populations and the lack of scientific studies on the fate of encircled individuals over the longer term, some tuna regional fisheries management organizations (RMFOs), e.g., Indian Ocean Tuna Commission (IOTC), Western and Central Pacific Fisheries Commission (WCPFC), and Inter-American Tropical Tuna Commission (IATTC), have prohibited the intentional setting of nets on whale sharks since September 2013 (IOTC Res[13/05]), January 2014 (WCPFC, CMM-2012-04), and July 2014 (IATTC, Res[C-13-04]) respectively.

It must be stressed that the whale shark has recently been listed as Endangered (June 2016, Vulnerable previously) by the International Union for Conservation of Nature, (IUCN; www.redlist.org), and is included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; www.cites.org) and in Appendix II of the Convention of Migratory Species of Wild Animals (CMS; www.cms.int). It is thus highly important to assess the potential impact of the tuna purse seine fishery on the species.

A previous study based on data from the French and Spanish scientific observer programs showed that the apparent immediate mortality of whale sharks from European purse-seiners' sets is very low (i.e., 0.93 and 2.53% for the 1995–2011 period in the eastern Atlantic and western Indian Oceans, respectively, knowing that observer coverage during these years represented approximately 10% of fleet activities, Capietto et al., 2014). In addition, preliminary results of longer-term post-release survival have shown encouraging results with the five whale sharks tagged in 2014 surviving at least 21 to 71 days after encirclement and release from tuna purse-seine nets (Escalle et al. 2014, 2016a, Murua et al., 2014). However, all these studies acknowledged the need to accurately quantify, through an increased sample size data, post-release mortality rates of whale shark encircled by tuna purse-seine nets and release using "best practice" and other release methods.

In this context, based on tagging experiments conducted in 2016 the aim of this study is to provide an update of the previous analyses (Escalle et al., 2014, 2016a), on the survival of whale sharks released from tuna purse seine nets.

2 Method

Whale sharks were tagged by scientific observers onboard French purse-seiners in the eastern Atlantic Ocean during fishing trips between June and September in 2014 and 2016 (observers were equipped in 2015 as well, but no tagging was conducted). This period of the year has previously been identified as having high numbers of whale sharks sightings and encirclement events (Capietto et al., 2014).

Tagging was performed at the end of the fishing set, when the whale shark was in the sack (i.e., prior to the release procedure) either before or after a first set of brailing had occured (see **Table 1**). Tagging was only possible when the whale shark was parallel to the vessel, with the dorsal fin visible at the surface. Tagging was conducted from the deck of the purse seine-vessel using a 4-meter tagging pole fitted with a titanium tag applicator (Wildlife Computers, USA). Pop-up archival tags (miniPATs, Wildlife Computers, USA) were externally attached to whale sharks using a titanium anchor implanted into the muscle below the dorsal fin. Pop-up tags were programmed to detach 30 (2014) or 180 (2016) days after the deployment. The miniPATS were equipped with guillotines which causes the tags to mechanically detach itself at depths of approximately 1800 meters, to prevent barometric damage to the tag. Furthermore tags were programmed to initiate a release when no change in depth (±2.5 m) occurred for a 72-hour period (i.e., to detect mortality in waters shallower than 1800 m).

Total length of the whale sharks were estimated using reference points on the deck and thereafter measured to the nearest 0.5 m. Sex was visually determined, when possible, by the presence or absence of claspers. Once tagged, whale sharks were release, when possible, following a “safe release” method (Poisson et al, 2014; Escalle et al., 2016a).

Descent speeds for each deep dive (>800 m) were calculated using top and bottom time and depth. These speeds were then used to compare the last dive of each individuals that led to the detachment of the tag.

3 Results

Five whale sharks were tagged in 2014 and another five were tagged in 2016. All the individuals for which sex was determined (i.e. 60%) were females, with a total length ranging from 8 to 12m (**Table 1**). Eight individuals were released using the “safe release” method described in Escalle et al (2016a). The size of shark n°2 (12m, **Table 1**) precluded the use of this method as the crew had problems sacking up the catch. The shark was therefore released by cutting a few meters of nets in front of the shark’s head, allowing it to swim out. In another instance (shark n°6, **Table 1**), the crew considered the safe release not to be working. Hence the whale shark was towed out of the net at the surface by the skiff using a rope attached to its caudal peduncle. The general state of all whale sharks was considered to be good at the time of release, with no visible injuries caused by the current encirclement and release processes. Release duration ranged between 2 to 38 minutes (overall time in the sack of 16 to 69 minutes).

Four tags detached at the programmed date (30 days after tagging), five tags detached prematurely (3 to 28 days after tagging) and one tag did not transmit (tag failure (software, release mechanism, battery failure) or transmission failure i.e., tag or antenna damaged by another organism).

Among the tags that detached prematurely three were mechanically induced when reaching a depth >1800m (sharks 4, 8 and 9, **Table 2 and Figure 1**) and one tag detach at a depth of 1336m for unknown reason (possible causes could be for instance that the tag tore out after being bitten by other animals or infection around the anchor, or tether failure possibly accelerated by biofouling or several deep dives). The last tag detached after 5 months, but only the first week of tracking reflects the depth profile of a whale shark (**Figure 1.c**). After 8 days, there is an apparent change in vertical behavior with depth records ranging between 700 and 1100m, with no return close to the surface. However before this change in vertical behavior, a last deep depth of 1752m was recorded by the tag.

The average descend speed of the deep dives (>800m, except last dive leading to detachment) recorded for all sharks was of 65.9 ±36.1 m/min. In comparison, the descent speeds for the last deep dives leading to detachment were of 55.6 (shark n° 4), 35.3 (shark n° 6), 48.0 (shark n°8) and 3.45 (shark n°9) m/min.

4 Discussion

This study complements previous results of post-release survival of five whale sharks tagged in 2014 (Escalle et al., 2014, 2016a), with five additional individuals tagged in 2016. It should be mentioned that Murua et al. (2014) also tagged a large whale shark (8m) in July 2014 in the same area of the Atlantic Ocean. Hence, the six whale sharks (five of them are included in Table 1 and 2, and the individual from Murua et al., 2014) tagged in 2014 were considered to have survived at least 21 days after encirclement. The recent whale sharks tagged (four when excluding the tag that did not report) brought new information, but the exact causes of tag detachment were not always clear.

Firstly, one shark survived at least 28 days after encirclement (shark n°6), with the detachment probably induced by a deep dive (last recorded depth of 1336m, descent speed of 35.3 m/min). Secondly, one tag detached after three days (shark n°8, **Table 2**), probably after a normal deep dive, as the descent speed (48.0 m/min) was very similar to the average descent speed recorded among all surviving whale sharks' deep dives (65.9 ±36,1 m/min). However with the detachment occurring after only three days at liberty, the longer term fate of this whale shark cannot be determined. Thirdly, one tag detached seven days after encirclement (shark n°9 see **Table 2** and depth profile in **Figure 1.b** and **1.d**). It also occurred after a deep descent to 2000m, but at a much slower speed than all other deep dives of the other whale sharks: 3.45 m/min (0.058 m/s). One interpretation of this atypical dive could be that it is the decent of a sinking tag still attached to something (minimum speed of sinking negatively buoyant minipat of 0.07 m/s, personal information from Kevin Lay, Wildlife Computers). Hence the speed indicates that this tag would unlikely be attached to a sinking dead whale shark, but rather to something just negatively buoyant enough to cause it to sink. This could, for example, perhaps be muscle tissue attached to the anchor of the tag, resulting from a predation event on the tag by another animal. A similar result (sinking speed = 3.26m/min = 0.054m/s), was observed from a tag deployed on a silky shark (1 m TL) for 16 days during a post release survival study (Poisson et al., 2014) but this was an outlier from the average sinking speed from tags known to be attached to silky sharks that sank directly after release (16.7 m/min) (John David Filmalter, unpublished data). As such the likelihood of this tag being attached to the whale shark during the observed descent appears to be small, however the exact fate of this animal cannot be determined with any certainty. Finally, the last tagged whale shark (shark n°10) showed very unusual depth profile (varying depth in the 700–1100m range) 8 days after tagging (**Figure 1.c**), following a deep depth recorded of 1752m. We may therefore hypothesize that the tag mechanically detach from the animal after reaching a depth ~1800m, and may have been ingested by a deep living animal on its way up to the surface. However the lack of information regarding the profile (and associated speed) of the last dive, also precluded any conclusion on the fate of this individual. It should be mentioned, that all tags deployed in 2016 were programmed to detach after 180 days. Hence, the amount of data to transmit via the Argos satellite system was considerably larger than tags recording data for only one month or less. This resulted in several periods of time with no depth record (see gaps in the depth profile, **Figure 1.c**). Programming tags to remain deployed for several months allow for the determination of the animals' movements, including those beyond the fishing area, while still detecting possible delayed mortality. However, while fine-scale movement (i.e. depth record every 5 minutes) is still recorded, not all information may be transmitted via the Argos satellite system. Such missing data is often less common when programming tags for shorter periods of time (30 days), but then long-term ecological information (horizontal and vertical movements) cannot be obtained.

Keeping in mind the low sample size of tagged individuals (5 + 1 (Murua et al, 2014) in 2014 and 3 in 2016), our result indicate survival rates following encirclement by purse seiner of 100% (90% if shark n°9 is considered a mortality). However the fate of four individuals remains unknown, as tags detached 3 or 7 days after encirclement or did not report. Scientific observers onboard French tuna purse-seiners have recorded 139 sets associated with as whale shark in the eastern Atlantic Ocean between 2014 and 2016. A total of 125 individuals were recorded effectively encircled during these years, with one record of mortality in 2015. Hence yearly apparent mortality rates since the observer coverage rate has increased to 100% are of 100% in 2014 and 2016 and 71% in 2015. As a precautionary approach, prohibited the intentional setting of nets around whale sharks could be considered in the Atlantic Ocean, as it is already the case in the western Indian, eastern Pacific and western and central Pacific Oceans. This measure could have relatively low impact on fishing strategy as whale sharks are rarely sighted prior the setting of the net, but could limit additional impacts on the population. In addition, a recent study based on real fishing data showed that a ban of whale shark associated sets in a large area off the western coast of Africa (i.e., where most whale shark associated sets occur) from July to September could have no effects on the tuna catch (considering the assumptions of a relocation of fishing effort on other fishing modes) (Escalle et al., 2016b). Furthermore there is a 100% observer coverage rate for the European fleet since 2014, which will exclude risk of under-declaration of whale shark encirclements by vessel captains.

Overall we recommend to perform more post-release tagging and especially additional studies on whale shark post-encirclement survival in all oceans and to keep avoiding, when possible, towing whale shark out of the net by the tail.

5 Conclusion

This study represents the second step of a tagging experiment started in 2014 in the eastern Atlantic Ocean. While the sample size is still too low to draw any conclusion on post-release survival rate, no mortality of whale shark following encirclement and release from tuna purse-seine nets have been recorded with certainty. Indeed it should be noted that the fate of several individuals could not be determined. It is still necessary to tag more individuals and to collect more information on the animal and setting conditions, in the eastern Atlantic Ocean, but also in other oceans, to precisely estimate post-release survival rates and define accurate conservation measures if needed.

Acknowledgements

The authors are grateful to the scientific observers involved in data collection. They thank the fishing masters, crew and their fishing companies for their collaboration in this experiment. The pop-up tags were funded by the ORTHONGEL-IRD project on bycatch mitigation. We thank Philippe Sabarros for providing whale shark apparent survival rates recorded by observers.

References

Ariz, J., Delgado, A., Fonteneau, A., Gonzales Costas, F., Pallares, P., 1999. Logs and tunas in the Eastern Tropical Atlantic. A review of present knowledge and uncertainties. In: Scott MD, Bayliff WH, Lennert–Cody CE, Schaefer KM (eds) Proceedings of the International Workshop on Fishing For Tunas Associated with Floating Objects, La Jolla, CA, February 11–13, 1992. Inter American Tropical Tuna Commission Special Report 11:195–221.

Capietto, A., Escalle, L., Chavance, P., Dubroca, L., Delgado de Molina, A., Murua, H., Floch, L., Damiano, A., Rowat, D., Merigot, B., 2014. Mortality of marine megafauna induced by fisheries: Insights from the whale shark, the world's largest fish. Biological Conservation 174: 147–151.

Escalle, L., Chavance, P., Amandé, J.M., Filmalter, J.D., Forget, F., Gaertner, D., Dagorn, L., Mérigot, B. 2014 Post-capture survival of whale sharks released from purse seine nets: preliminary results from tagging experiment. Collective Volume of Scientific Papers ICCAT SCRS/2014/135

Escalle, L., Murua, H., Amandé, J. M., Arregui I., Chavance, P., Delgado de Molina, A., Gaertner, D., Fraile, I., Filmalter, J. D., Santiago J., Forget F., Arrizabalaga H., Dagorn L., Mérigot, B. 2016a Post-capture survival of whale sharks encircled in tuna purse-seine nets: tagging and safe release methods. Aquatic Conservation 26(4):782–789.

Escalle, L., Gaertner, D., Chavance, P., Delgado de Molina, A., Ariz, J., Mérigot, B. 2016b Consequences of fishing moratoria on catch and bycatch: the case of tropical tuna purse-seiners and whale and whale shark associated sets. Biodiversity and Conservation 25(9): 1637–1659.

Escalle, 2016 Spatio-temporal interactions between whale sharks, cetaceans and tropical tuna purse-seine fishery, within a conservation perspective, in the Atlantic and Indian Oceans. PhD thesis from the Université de Montpellier.

Hall, M.A., 1998. An ecological view of the tuna-dolphin problem: impacts and trade-offs. Reviews in Fish Biology and Fisheries 8: 1–34.

Matsunaga, H., Nakano, H.,Okamoto, H., Suzuki, Z., 2003. Whale shark migration observed by pelagic tuna fishery near Japan. SCTB 16 Working Paper from 16th Meeting of the Standing Committee on Tuna and Billfish at Mooloolaba, Australia. BBRG-12: 7.

Murua, H., I. Fraile, I. Arregi, A. Delgado de Molina, J. Santiago, H. Arrizabalaga, G. Merino and J. Ariz. 2014. Investigating the post-release survivorship of whale sharks encircled by European purse seiners: first insight from electronic tagging. Collective Volume of Scientific Papers ICCAT SCRS/2014/180.

Poisson, F., Séret, B., Vernet, A.-L., Goujon, M., Dagorn, L., 2014. Collaborative research: Development of a manual on elasmobranch handling and release best practices in tropical tuna purse-seine fisheries. Marine Policy 44 : 312–320.

Poisson, F., Filmalter, J. Vernet, A.-L., Dagorn, L., 2014. Mortality rate of silky sharks (*Carcharhinus falciformis*) caught in the tropical tuna purse seine fishery in the Indian Ocean. Can. J. Fish. Aquat. Sci. 71(6): 795-798.

Romanov, E.V., 2002. Bycatch in the tuna purse-seine fisheries of the western Indian Ocean. Fishery Bulletin 100: 90–105.

Rowat, D., Brooks, K.S., 2012. A review of the biology, fisheries and conservation of the whale shark *Rhincodon typus*. Journal of fish biology 80: 1019–1056.

Stretta JM, Slepoukha M. 1986 Analyse des facteurs biotiques et abiotiques associés aux bancs de listaos. Proceeding of the ICCAT conference on the international skipjack year program 1:161–169.

Table 1. Summary information of the whale sharks tagged in the eastern Atlantic Ocean.

Shark n°	Tagging date	TL[6] (m)	Sex[7]	Release	Period of release	Release duration	Time spent in the sack	Particular observations
1	03/07/14	11	F	Over the cork line	After first set of brailing	18	38	-
2	05/07/14	12	-	Net cut	Before brailing	2	25	-
3	24/07/14	8.5	F	Over the cork line	After first set of brailing	10	25	-
4	24/07/14	10	F	Over the cork line	After first set of brailing	20	45	-
5	24/07/14	8.5	F	Over the cork line	After first set of brailing	15	30	-
6	19/06/16	10	-	Over the cork line (fail) Pulled by the tail	After first set of brailing	38	69	-
7	20/06/16	8	-	Over the cork line	After first set of brailing	7	30	-
8	23/06/16	12	F	Over the cork line	Before brailing	17	25	Traces of old injuries (ventral face and tail)
9	27/06/16	10	F	Over the cork line	Before brailing	6	16	-
10	27/06/16	11	-	Over the cork line	Before brailing	20	27	-

Table 2. Tagging and tag detachment information of the whale sharks tagged in the eastern Atlantic Ocean. Tags were programmed to pop-up 30 days after tagging in 2014 and 180 days after tagging in 2016.

Shark n°	Tag n°	Tagging date	Latitude tagging	Longitude tagging	Date detach.[8]	Detach.	Latitude detach.	Longitude detach.	Last position[9]	Tacking duration	Depth last dive[9]
1	11P0095	03/07/14	-2.82	8.12	02/08/14	Prog.[10]	-2.82	8.13	-	30	-
2	11P0122	05/07/14	-2.68	8.48	04/08/14	Prog.	-2.68	8.48	-	30	-
3	11P0285	24/07/14	1.70	3.28	23/08/14	Prog.	1.70	3.28	-	30	-
4	11P0283	24/07/14	1.83	3.60	14/08/14	Deep dive	1.83	3.60	11/08/16	19	1912
5	10P0458	24/07/14	1.75	3.38	23/08/14	Prog.	1.75	3.35	-	30	-
6	09P0346	19/06/16	-3.46	8.66	18/07/16	Deep dive?	-3.29	7.60	15/07/16	28	1336
7	10P0456	20/06/16	-3.77	8.21		No data					
8	11P0266	23/06/16	-3.92	7.83	28/06/16	Deep dive	-3.97	6.02	25/06/16	3	1808
9	10P0440	27/06/16	-3.63	9.04	07/07/16	Deep dive	-3.51	7.87	03/07/16	7	2000
10	10P0366	27/06/16	-3.62	9.04	18/12/16	Deep dive	-2.00	1.58	03/07/16	7	1752

[6] Total length
[7] "F" = Female, "-" = Sex unknown
[8] Detachment
[9] For premature detachment, last recorded position of the tag attached to the whale shark.
[10] Detachment at programmed date

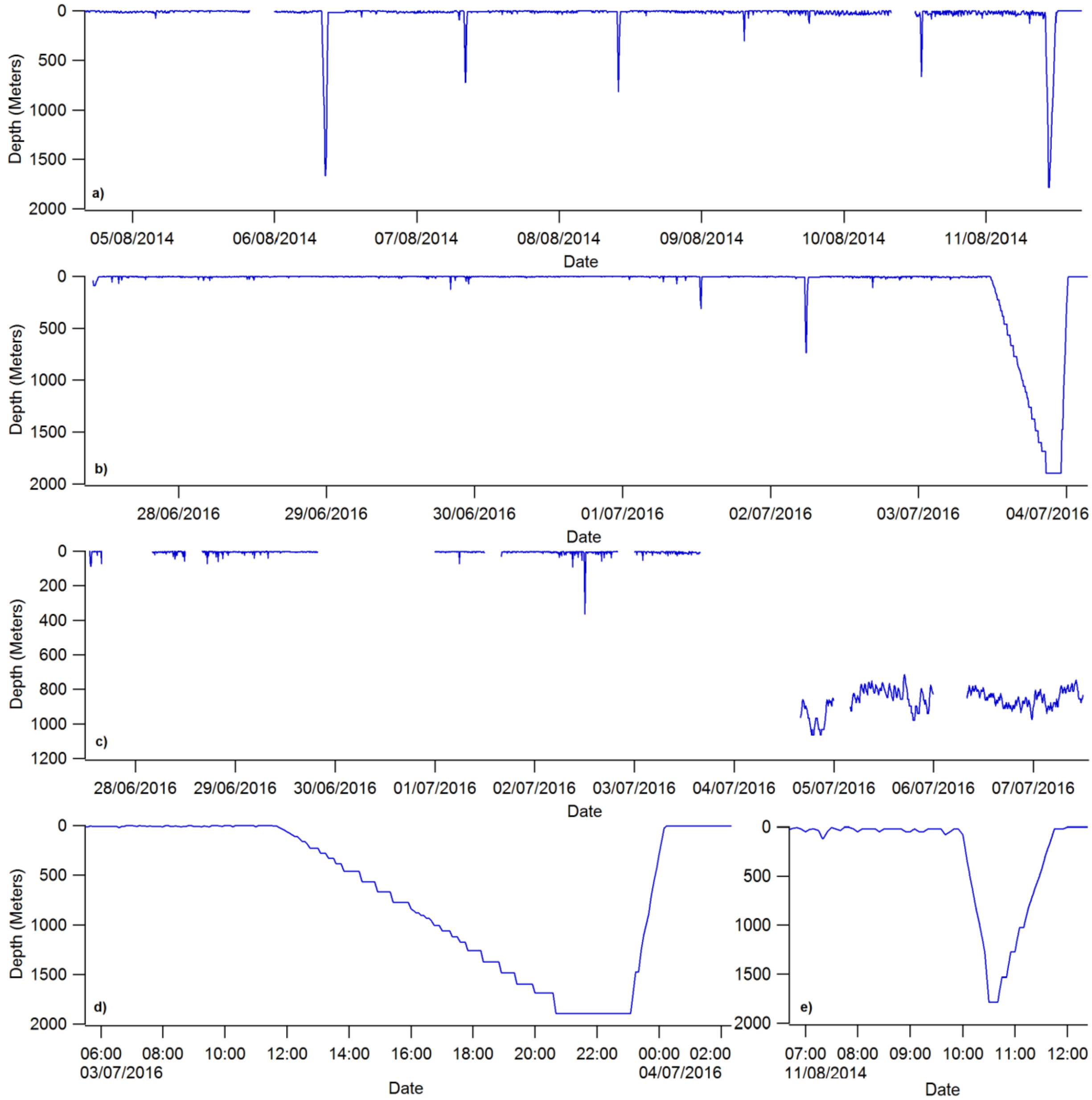

Figure 1. Depth profiles of the last 7 or 9 days for shark: a) n°4, b) n°9, and c) n°10; and zoom on the last dive of sharks d) n°9 and e) n°4.