Canaries Angel Shark Project: Engineering a solution to track Critically Endangered Angelsharks

Final Report, August 2018

David MP Jacoby[1], Eva KM Meyers[2], David Jimenez Alvarado[3], Luka Mustafa[4,5], Blaz Bratus[4], Alasdair Davies[5,6], Matthew Gollock[6], Stuart Hetherington[7] & Joanna Barker[6]

[1]Institute of Zoology, Zoological Society of London, UK
[2]Zoological Research Museum Alexander Koenig, DE
[3]University of Las Palmas de Gran Canaria, ES
[4]Institute for development of advanced applied systems Rače, SI
[5]The Shuttleworth Foundation
[6]Conservation Programmes, Zoological Society of London, UK
[7]Centre for Environment, Fisheries and Aquaculture Science, UK

NATIONAL GEOGRAPHIC

Oceanário de Lisboa

OCEAN TRACKING NETWORK

ARRIBADA initiative

Executive Summary

Once relatively abundant in European coastal waters, the Angelshark (*Squatina squatina*) is today listed as Critically Endangered on the IUCN Red List. There remains however a distinct lack of data available for this species on their life history, distribution, ecology and habitat requirements and further research is imperative to secure their future. The Canary Islands have been identified as a unique stronghold for the Angelshark, where they are regularly sighted by divers and fishers. However, here too they are under significant threat from incidental catch in commercial and recreational fisheries; habitat degradation from pollution, coastal development and marine infrastructure; and disturbance by divers and beach users.

Limited understanding of adult Angelshark habitat use, movement and site fidelity is a major factor preventing effective species protection in the Canary Island stronghold. Without this baseline ecological data, the efficacy of management decisions and conservation initiatives cannot be assessed. This project, funded by Oceanário de Lisboa, National Geographic, the Ocean Tracking Network and the Arribada Initiative, was developed to try and aid this critical knowledge gap through employing electronic tracking technology to provide detailed, round-the-clock ecological data to the Canary Island and Spanish Governments enabling them to better protect Angelsharks in their waters.

Due to the sensitivities of catching Angelsharks for research purposes, the first stage of the project involved designing and developing a low cost, open source and ethically sound tag attachment methodology. This methodology was meticulously designed by a collaboration of ecology and fisheries scientists, conservationists, engineers and an ethical review board, to enable the *in situ*, external attachment of an acoustic tag to an Angelshark. Conducted on resting individuals whilst diving the method was designed to cause minimal disturbance and stress to the fish.

With a new attachment method designed, delivered and tested during the early summer of 2018, the second phase was to establish the first acoustic telemetry project for Angelsharks. During a preliminary expedition at the end of July 2018, seven acoustic hydrophones were deployed on moorings around the La Graciosa Marine Reserve north of Lanzarote. A total of nine acoustic tags have been successfully deployed on adult individuals to date with a view to a follow-up expedition in November 2018 to deploy a further 15 tags. The acoustic receivers are now listening round-the-clock for these tagged individuals and a thorough appraisal and refinement of the tagging method in practice continues to be carried out. Under tight budget conditions and through engaging broad collaboration and expertise, the project has exceeded expectations and although no data has yet been retrieved, huge steps have already been made towards better understanding and monitoring this species into the future.

Introduction

Angel sharks are large, flat-bodied sharks that live in coastal marine habitats, to at least a 200m depth (Ferretti *et al*. 2015). Three species of angel shark (Angelshark (*Squatina squatina*), Smoothback Angelshark (*Squatina oculata*) and Sawback Angelshark (*Squatina aculeata*)) were once widespread throughout the Eastern Atlantic and Mediterranean Sea, but have suffered severe declines across their range. They were initially targeted as a food source, but have suffered steep declines throughout their historic range during the last century, mainly attributed to increasingly intensive demersal fishing practices (e.g. trawling and dredging) (Barker *et al.* 2016). These slow-growing and late-maturing species have disappeared from much of their former range and are likely no longer present along much of the coastal shelf of Europe (Gordon *et al.* 2017). In 2015, all three angel shark species were assessed as Critically Endangered on the IUCN Red List of Threatened Species (Ferretti *et al*. 2015). Furthermore, in 2014 the angel shark family was identified as the second most threatened elasmobranch taxa after a global review of extinction risk by the IUCN Shark Specialist Group (Dulvy *et al.* 2014).

Today, information on *S.oculata* and *S.aculeata* is severely lacking, but the Canary Islands have been identified as a unique stronghold for the Angelshark (*S. squatina)*, where the species is still regularly sighted by divers (Meyers *et al*. 2017). The Zoological Society of London (ZSL), Universidad de Las Palmas de Gran Canaria (ULPGC) and Zoological Research Museum Alexander Koenig (ZFMK) set up the collaborative Angel Shark Project (ASP) in 2013. The aim of the ASP is to secure the future of the Critically Endangered angel sharks throughout their range. Over the last five years, the ASP has become the established authority for angel shark conservation and research in Europe, through investigating angel shark ecology, delivering important conservation projects and developing the networks needed to complete successful conservation and research on a wider scale. The ASP made the strategic decision to initially prioritise conservation work in the Canary Islands, the identified unique stronghold for the species, as a first step in securing the future of the Angelshark.

However, even within the Canary Islands, Angelsharks are under significant threat from incidental catch in commercial and recreational fisheries; habitat degradation from pollution, coastal development and marine infrastructure; and disturbance by divers and beach users (Barker *et al.* 2016). At the same time, such activities contribute to financial, recreational, and well-being benefits to the human population, making the management of these activities and the protection of the species a multi-dimensional issue. Accounting for the impacts of human activities is exacerbated by a lack of data to inform appropriate conservation measures; an

absence of protective legislation; and little local awareness of the importance of the Canary Islands to Angelsharks (Barker *et al.* 2016).

The challenge

One major challenging inhibiting the conservation of this species is how little knowledge we have on its current distribution, life history or even its basic ecology. How far do they move? How does the environment drive their space use patterns? Given their listing of Critically Endangered on the IUCN Red List, it is unsurprising that there are few opportunities to gather this crucial data and in a way that least impacts both the individual and the population.

In October 2017, ZSL organised an Angelshark acoustic tag attachment workshop to bring together key researchers to discuss and identify the best approach to externally tag Angelsharks with electronic tags, whilst ensuring minimal impact on animal behaviour and life history. There were 11 people in attendance, including Angelshark researchers from ULPGC, ZFMK and ZSL; professionals from ZSL's Conservation Programmes, a conservation technology specialist from Arribada Initiative; tagging specialists from Centre for Environment Fisheries and Aquaculture Science (Cefas) and the Institute of Zoology; and engineers from Institute IRNAS Rače. The multidisciplinary background of the workshop attendees was designed to stimulate and generate discussion around old and new approaches to shark tagging and the potential implications of these for animal welfare and project success.

The workshop group discussed the advantages and disadvantages of both external and internal tagging methodologies. However, Angelsharks needed to be tagged underwater (i.e. not fished as is usual for tagging many shark species), partly due to their Critically Endangered status but also to ensure consistency with the ASP sportfisher programme, which focuses on working with fishers to change their behaviour to not target Angelsharks and appropriately handle those sharks still accidentally caught. As such, only an external tag attachment methodology was viable as surgery cannot be executed accurately on large sharks whilst SCUBA diving. The proposed methodology also had to account for several issues related to specifics of both Angelsharks themselves and the areas they inhabit.

- Angelsharks are normally found on benthic soft sediments to at least a 200 m depth; attachment device could not therefore be placed on the ventral (underside) surface the shark.
- Angelsharks use their broad pectoral fins to bury themselves in the sand and for swimming and so the attachment device could not be placed on pectoral fins as it would disturb burying/swimming behaviour.

- Camouflage is important as Angelsharks are ambush predators, attacking unsuspecting fish that swim within reach; the attachment had to be inconspicuous, appropriately coloured (e.g. sand colouration) and must not protrude out of the sand when attached (ruling out tethered tags).
- The large diving community in the Canary Islands may be curious when they see a tagged Angelshark; the attachment therefore must include a tag number and contact details so that tagged Angelsharks can be reported by recreational divers to the ASP sightings map.
- Male Angelsharks reach maturity at 80 – 132cm and females 126-169cm. When mating, the male Angelshark bites onto the female Angelsharks pectoral fin in an aggressive and quick behaviour and so any tags must not be placed on pectoral fin and must be robust, but flexible, so as not to restrict movement of the animal.
- Angelsharks range from 20cm to 240cm in length, but we were specifically targeting adult Angelsharks between 80cm and 150cm (the largest Angelshark visually ID tagged underwater was 130cm, any larger will be difficult to control with the restraining device); attachment device needs to be scalable for different sizes of sharks allowing some room for growth; importantly we did not know what size of shark would be encountered prior to getting in the water.
- Angelshark skin is particularly tough on the dorsal surface, making some visual ID tagging methods unsuitable (e.g. dart tags).
- Angelsharks produce a lot of mucus exuded from the skin surface when stressed; attachment cannot prevent mucus production and must be breathable.
- Angelsharks have a protruding jaw which can move upwards at a 45° angle at fast speed; ideally, the tag would be attached somewhere on the tail/latter half of the Angelshark (e.g. between the first and second dorsal fin) as this is further from the head and easier/safer to attach when restrained underwater.

In short, a quick attachment method was needed: Angelsharks needed to be restrained underwater during SCUBA diving, using a bespoke and well tested restraining device used on 60 individuals to date for visual ID tagging. All the tagging components needed to be ready before entering the water, so only a simple procedure is needed when the shark is restrained. We therefore envisioned a procedure that would take less than two minutes to perform (including restraint, tagging and genetic sampling protocols).

The solution

Following the workshop, it was concluded that the most suitable tag attachment option would be a *fin puncture* with a modified cattle tag at the base of the first dorsal fin. This method had the advantages of good retention if secured close to base of first dorsal fin where fin rays are present; applicator could be modified to take genetic sample at the same

time; if coloured appropriately quite inconspicuous to divers; relatively cheap and relatively short development timeline (compared to making brand new product); demonstrated use on sharks enabling background information for ethical approval. The only drawbacks were that the standard tag pin might not pass easily through Angelshark's skin; standard tag applicator might not provide enough force.

Working closely with our project partners at IRNAS, both the tag harness and attachment device went through a number of iterations and rigorous testing in both the engineering laboratory (e.g. stress testing, visibility) and in ZSL's post-mortem room where we were able to obtain some specimens of smoothound (*Mustelus mustelus*) through Cefas to trial the attachments and give feedback to the next phase (Fig. 1). Smoothound were chosen as having one of the more similar dorsal fin types to Angelsharks whilst still being local accessible at fish markets. These trials on deceased sharks proved invaluable to the developmental process. The whole development process, including in water testing, biofouling trials and all engineering developmental stages is outlined in detail in the attached appendix, should you require more information on the process. As we intend to make the tag harness and attachment open source as a solution for tagging flat sharks *in situ*, thorough testing and rigorous ethical review was fundamental.

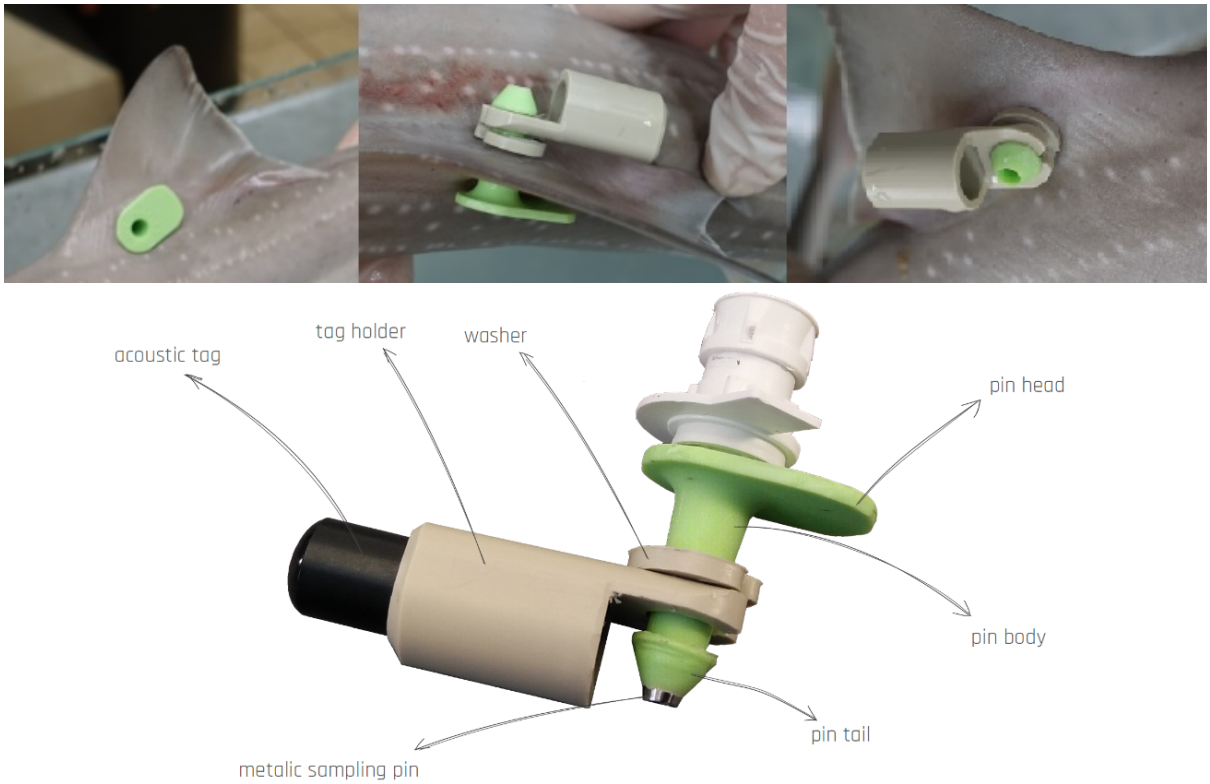

Figure 1. The final product, a bespoke tag attachment harness for in situ tagging of Angelsharks. The tag is displayed during trials on a deceased smoothound (above) and highlighting the different components (below). The tag holder has an email and phone number label on the inside and the metallic sampling pin takes a genetic sample during attachment, removing the necessity of two

separate procedures underwater. The pin head was eventually constructed in red as red light attenuates easily in water.

The product completed development, testing and ethical review in June 2018. The current version fit for trial on Angelsharks is shown in Figure 1 and the applicator and tag fit in Figure 2. This then enabled us to move on to the second phase of the project to establish an acoustic array in the Canaries to monitor and track acoustically tagged Angelsharks.

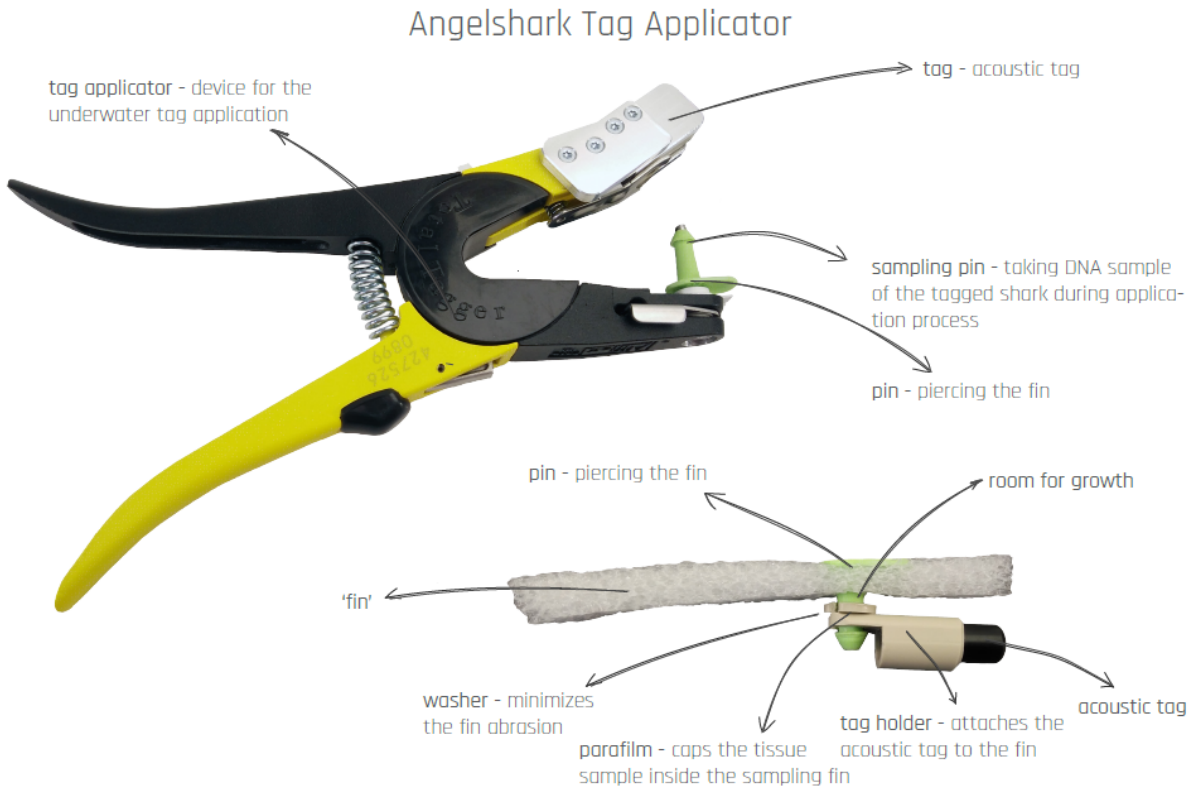

Figure 2. Tag applicator for in situ tagging. These applicators were adapted from existing pin applicators to fit our purpose whilst also adhering to our goal of producing a low-cost device.

Results and Discussion

During a 10 day expedition to the La Graciosa Marine Reserve, located north of Lanzarote in the Canary Islands, a team of research staff from ZSL, ULPGC and ZFMK trailed the newly developed tag attachment methodology for the first time on free-swimming Angelsharks. Acoustic receiver moorings were built on the island and all seven of our receivers were deployed around the main island of La Graciosa, found at the centre of the reserve (Fig. 3), with six of these receivers kindly loaned to the project by the Ocean Tracking Network ensuring that the data feed into globally relevant databases.

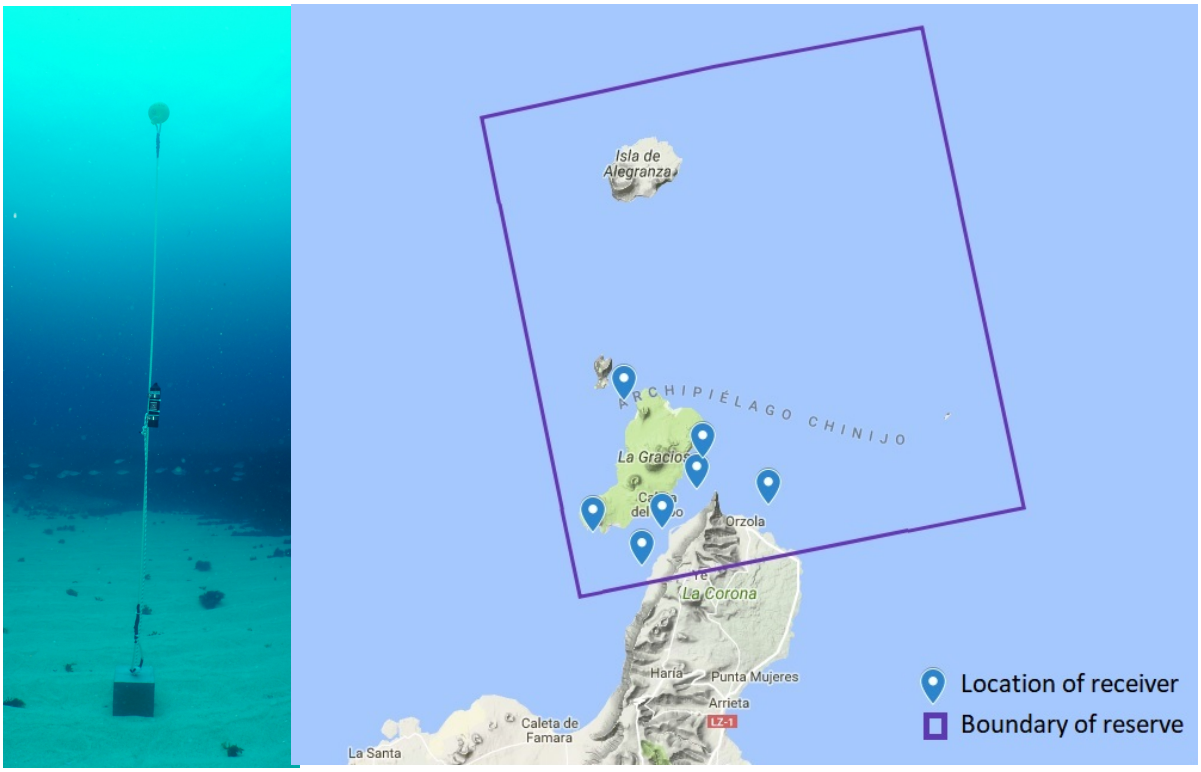

Figure 3. Acoustic receiver moored in the marine reserve and geographic distribution of our seven receivers.

We were able to range test three of the seven receivers but were limited by the weather in testing the remaining four. It is hoped that these will be tested in November 2018. Diving three times a day, we were also able to deploy nine of our 24 acoustic transmitters on Angelsharks that ranged in size from 110 cm to 120 cm. Although difficult to find (almost all sharks we encountered were completely buried in the sand) and restricted to individuals on soft substrate (some individuals were located on rock which precluded the use of the net to restrain them), these nine provided invaluable for refining the tagging technique *in situ*. The result was development of a process that not only relied on the way in which we had designed and engineered the technique, but also on the logistics of the application itself. For example, we had a couple of snapped pins during the first few deployments, but fortunately we designed the applicator such that we were able to reload underwater and still able to tag. During a series of refinements to the procedure underwater (Fig. 4), this issue was rectified by re-orientating the tagger to a 90 degree position to the shark and fin, rather than a 45 degree angle.

Figure 4. Tagging procedure, with two restraining the shark (foreground), one tagger (centre back) and tag assistant (right back) and one individual taking measurements notes (left back).

All tagged individuals were observed for as long as we could swimming immediately after the tagging event and where possible, images were taken of the tag attached to the first dorsal fin. During this time we were also able to sex the shark suggesting a female bias in the individuals we tagged (F:M = 7:2). The tags appeared to sit well on the dorsal fin and genetic samples were successfully taken for six out of the nine tagged individuals (Fig. 5).

Figure 5. Deployed tag situated on the first dorsal fin of an adult female Angelshark. The low drag harness design will also hopefully reduce debris build up, however we have also built in a weak point to the harness meaning the tag can pull away from the pin if caught on anything (see appendix for details).

While the deployment of nine tags is still low, this expedition marks a huge step forward in the development of this methodology and in more widely in gaining the first knowledge on the round-the-clock residency patterns of Angelsharks to the shallow waters of the Canary Islands, one of the only places in the world where these animals can reliably be sighted. As such we are excited to continue to develop the methodology and by the prospect of retrieving any data from our receivers in July of 2019. The project is very much in its infancy but is already engaging individuals from the local dive community, raising the profile of these sharks further still in the public eye. This project will continue over the next year, through the ASP continuing to record and explore Angelshark sightings submitted by the local dive community and it is hoped that a further 15 tags can be deployed in the coming months.

Acknowledgements

This work would not have been possible without the funding support of Oceanario de Lisboa, National Geographic, the Ocean Tracking Network, Save Our Seas Foundation and the Arribada Initiative. We would like to thank the Government of Gran Canaria and the management of the La Graciosa Marine Reserve for their permission to conduct the work inside this protected area. The authors are also extremely grateful to Michael Sealey for photography support, to the Cetacean Strandings Investigation Programme and ZSL Aquarium for organising use of the laboratory for testing tags and Buceo La Graciosa, the dive centre on La Graciosa through whom the fieldwork was made possible through logistical support and local knowledge.

References

Barker, J., Bartoli, A., Clark, M., Dulvy, N.K., Gordon, C., Hood, A., Alvarado, D.J., Lawson, J. & Meyers, E. (2016) Angelshark Action Plan for the Canary Islands. *ZSL*.

Dulvy, N.K., Fowler, S.L., Musick, J.A., Cavanagh, R.D., Kyne, P.M., Harrison, L., Carlson, J., Davidson, L., Fordham, S., Francis, M., et al. 2014. Extinction risk and conservation of the world's sharks and rays. *eLife* vol. 3 p. e00590.

Ferretti, F., Morey, G., Serena, F., Mancusi, C., Fowler, S.L., Dipper, F., & Ellis, J. 2015. Squatina squatina. *The IUCN Red List of Threatened Species 2015*: e.T39332A48933059. http://dx.doi. org/10.2305/IUCN.UK.2015-1.RLTS.T39332A48933059.en

Gordon, C.A., Hood, A.R., Barker, J., Bartolí, À., Dulvy, N.K., Jiménez Alvarado, D., Lawson, J.M., and Meyers, E.K.M. 2017. Eastern Atlantic and Mediterranean Angel Shark Conservation Strategy. *The Shark Trust*, Plymouth, United Kingdom.

Meyers, E.K.M., Tuya, F., Barker, J., Jiménez Alvarado, D., Castro-Hernández, J.J., Haroun, R. & Rödder,D., 2017: Population structure, distribution and habitat use of the Critically Endangered Angelshark,*Squatina squatina*, in the Canary Islands. Aquat. Conserv.-Mar. Freshw. Ecosyst., 1-12.