Version of Record: https://www.sciencedirect.com/science/article/pii/S0165783619301596
Manuscript_689624fc76b9b8676dee2375a2060337

Post-release survivorship and movements of bigeye thresher sharks, *Alopias superciliosus*, following capture on deep-set buoy gear.

C.A. Sepulveda‡, M. Wang, S.A. Aalbers

Affiliation: Pfleger Institute of Environmental Research (PIER), Oceanside, CA 92054

Running head: Bigeye thresher survivorship

‡ Author to whom correspondence should be addressed: C.A. Sepulveda, Pfleger Institute of Environmental Research, Oceanside, CA 92054 USA Email: chugey@pier.org Phone (760) 721-1404 Fax (760) 721-1475

Abstract

The bigeye thresher shark (*Alopias superciliosus*) is a large pelagic predator routinely caught in a new deep-set fishery off California. Deep-set buoy gear (DSBG) was recently developed to selectively target swordfish (*Xiphias gladius*) at depth during the daytime and is currently being trialed by a limited fleet of vessels operating under an exempted fishing permit (EFP) issued through the National Marine Fishery Service (NMFS) and Pacific Fisheries Management Council (PFMC). Although marketable, bigeye thresher sharks (BETS) are often released or discarded to conserve limited hold space for more valuable catch. This study outfitted BETS with pop-up satellite archival transmitters (PSATs) programmed for 30-day deployments to evaluate acute post-release survival in the DSBG fishery and begin to understand depth and temperature distribution for this poorly known species. Fourteen BETS (43-93 kg) were tagged from 2016 to 2018 with PSATs (Wildlife Computers sPATs and MiniPATs) following fight times that ranged from 15 to 171 minutes. Out of the 14 deployments, twelve individuals survived the acute effects of capture, one BETS died shortly after release and one individual was preyed upon 6h after release. Given the lack of information surrounding the predation induced mortality, two survivorship estimates are provided, one that includes the event as a mortality resultant of the capture event (86% survivorship) and one that excludes the event from the analysis (92% survivorship). All surviving BETS exhibited consistent diurnal dive patterns in which the sharks remained below the thermocline during the day and within the mixed layer at night. Mean daytime depths ranged from 250 to 439m, while mean nighttime depths ranged from 20-106m. Daytime temperatures at depth ranged from 6-10°C with the lowest temperature value (6.0°C) recorded on the deepest dive (548 m). For all BETS, maximum night temperatures averaged from 22.5-25.1°C. Two tagged individuals remained proximal to the study area (<150 km) with others moving up to >1,300 km from the tagging site (mean = 1,009 ± 455 km). Mean daily rates of horizontal movement ranged from 3.4 to 41.6 km day^{-1}. The most common movement trend entailed BETS moving in a southerly direction towards a series of offshore seamounts along southern Baja California, Mexico (22°-26°N and 114°-126°W), a purported offshore corridor for other large pelagic sharks of the eastern Pacific.

Key Words: Thresher shark, Alopias, survivorship, mortality, fishery

1. Introduction

The bigeye thresher shark (BETS) is a slow-growing pelagic species (female growth coefficient (*k*) ~ 0.06yr^{-1}; Fernandez-Carvalho et al., 2011) with a broad geographic distribution that extends across both temperate and tropical seas (Gruber and Compagno, 1981; Nakano et al., 2003; Chen et al., 1997). Given its large size at maturity (~3.0 m total length) and low fecundity (~2 pups/litter), BETS have a low intrinsic rate of increase and the lowest rebound potential of the three Alopiid shark species (Fernandez-Carvalho et al., 2015). Although frequently encountered in open ocean fisheries, BETS are poorly studied, with little information existing on their general biology, population dynamics or current stock status (Preti et al., 2008; Fernandez-Carvalho et al., 2011).

In the eastern north Pacific, BETS are landed in several fisheries including the California drift gillnet fishery (DGN) as well as national and international longline fisheries that operate outside of the U.S. exclusive economic zone (EEZ) and along the Mexican coastline (Hanan et al., 1993; Fernandez-Carvalho et al., 2011). Although marketable, BETS have limited value in U.S. fisheries and are often discarded, as hold space is typically reserved for more lucrative species, like swordfish (*Xiphias, gladius*) (Sepulveda and Aalbers, 2018). However, in neighboring fisheries off the coast of Baja California, Mexico, BETS are a welcome incidental species that are retained for sale by the local longline industry (pers. Comm. O. Nishizaki-Sosa; Ensenada BCN, MX).

From an ecological perspective, the BETS is a highly migratory shark species that seasonally inhabits the Southern California Bight (SCB) during the summer and fall months (Hanan et al., 1993; Preti et al., 2008; Sepulveda and Aalbers, 2018). Although BETS are commonly observed in the commercial catch records for fisheries that occur at night (i.e., DGN, shallow set longline), this species is rarely observed during the daytime, most likely due to its near absence from epipelagic waters during day (Nakano et al., 2003; Weng et al., 2004). Although movement data for BETS in the Pacific is limited to only a few individuals, daytime depth distribution has been shown to be almost entirely below the thermocline (ranging from 200-500m) while nocturnal movements are predominantly within the upper-mixed layer (<100m; Nakano et al., 2003; Weng et al., 2004). Despite the lack of movement studies off California, diet analyses suggest that diel vertical movements may be similar to that of BETS tagged in other locations, as California BETS have been shown to prey upon a wide range of both deep-water (including organisms of the deep-scattering layer, DSL) and epipelagic species (Preti et al., 2008). BETS are a common catch of most swordfish operations in the Pacific most likely because food habits and diel movement patterns are very similar to those documented for swordfish (Preti et al., 2008; Hanan et al., 1993; Sepulveda and Aalbers, 2018).

Off Southern California, BETS are also caught in a new and developing deep-set fishery (i.e., deep-set buoy gear, DSBG) that targets swordfish at depth during the day (Sepulveda et al., 2014; Sepulveda and Aalbers, 2018). Although California deep-set operations have proven to be highly selective for swordfish (>80% target); BETS continue to comprise a significant portion of the catch (Sepulveda et al., 2014; Sepulveda and Aalbers; 2018). Unlike neighboring longline operations in Mexico, BETS captured in the CA DSBG fishery are generally released, as market price and local demand are low (Sepulveda and Aalbers, 2018). Because there are no data on the movements or depth distribution of BETS in southern California, it is unknown if tailoring or adjusting daytime hook depth can be used to avoid BETS. Further, it is also not known whether BETS released from California deep-set operations survive the effects of capture.

Documenting fishery impacts on both target and non-target catch is critical for sustainable fishery development and effective management. Given the recent interest in developing deep-set fisheries within the U.S. West Coast exclusive economic zone (EEZ) and the lack of disposition data for this species, the present study focused on assessing post-release survivorship of BETS captured using DSBG. Secondarily, this work also focused on documenting vertical movements of BETS to assess if depth can be used to further increase selectivity for swordfish in the DSBG fishery.

2. Methods

Tagging operations were performed within the SCB between Santa Cruz Island (33°.91/-119°.70) and Carlsbad, CA (33°.24/-117°.68) from October 24, 2016 through September 23, 2018 (Figure 1). All tags were deployed either from the PIER (Pfleger Institute of Environmental Research) research vessel *Malolo* (n=4) during experimental DSBG trials or from the cooperative fishing vessel *Gold Coast* (n=10) while operating under the PIER DSBG Exempted Fishery Permit issued through NMFS and the PFMC. Gear configurations and fishing techniques were standardized to align with current DSBG EFP terms and conditions and have been detailed previously (Sepulveda et al., 2014; Sepulveda and Aalbers, 2018). Briefly, non-offset 18/0 circle hooks were baited with either chub mackerel (*Scomber japonicas*) or squid (*Illex,* spp.) and rapidly descended using a 3.6 kg lead sinker to a target depth between 250-350m. Following DSBG protocols, each piece of gear was outfitted with an inline float system that functioned as a strike indicator to allow fishers to detect when something was on the line (Figure 2). All DSBG sets were actively monitored and immediately tended upon visual detection of a strike (either when all buoys were floating at the surface or when more than one buoy was subsurface; Figure 2). Upon detection of a strike, time was noted and the vertical mainline was retrieved using a hydraulic line puller (Custom Sea gear; Odessa, FL USA).

Upon capture, BETS were leadered along the side of the vessel, size was measured (FL) or estimated by the fisher and sex was determined when possible. Hook position was noted and the shark was outfitted with a satellite tag positioned in the dorsal musculature. Tags were tethered using a 10-cm monofilament leader anchored using a plastic umbrella dart as outlined in Heberer et al. (2010). Tag location and shark condition were noted prior to release, which typically entailed cutting the monofilament leader near the hook using an extended line cutter. Fight duration was defined as the time from observation of the initial strike to the time of release. For those sharks captured by the research vessel (4), depth of capture, fight time and haulback duration were determined from time depth recorders that were positioned on each gangion (Cefas Technology Limited; Lowestoft, UK).

2.1 Post-Release Disposition

This work determined post-release disposition using established protocols based on depth, temperature and satellite tag technology (Heberer et al., 2010; Sepulveda et al., 2015; Goldsmith et al., 2017). Briefly, tags were programmed to remain affixed to the shark for 30d and release prematurely to initiate data transmission if depth values remained constant (± 5 m) over a 24-h period, consistent with a mortality or shed tag. Disposition was determined by evaluating changes in depth, temperature, and light levels (light was only recorded for the MiniPAT deployments) following previous survivorship protocols (Graves et al., 2002; Horodysky and Graves, 2005; Heberer et al., 2010; Goldsmith et al., 2017).

Predation induced mortality was also determined using the depth, temperature and light records following established protocols of past tagging studies (Tracey et al., 2016; Goldsmith et al., 2017). For the one predation event (tag #16P2166) recorded in this study, the complete data archive (1-s resolution) was downloaded directly from the sPAT as it was subsequently recovered after the tag washed ashore along a southern California beach. Given the uncertainties that surround predation events, the survivorship estimate for this study is presented with both the predation event included as a capture induced mortality as well as excluded from survivorship analyses (see results and discussion for details).

2.2. Tag Specifications

Two varieties of pop-up satellite archival tags (Survivorship PATs and MiniPATs) were used in this study (Wildlife Computers, WC ; Redmond, Washington, USA). Both tag types were identical in size (60g), deployment duration (30 d) and configuration, yet they differed in cost and data transmission capacity. WC MiniPATs transmit detailed depth, temperature and light data for movement analyses while sPATs provide summary data for the last five days and only offer the full data archive if recovered and downloaded manually. In this study, two MiniPATs were deployed to obtain movement data over the entire 30-d deployment period (10-min resolution) and twelve sPATs were used to primarily assess post-release disposition.

2.3. Movement Data

Transmitted depth and temperature data from the 12 successful deployments were formatted to Pacific Standard Time and records were categorized into day, night, and twilight periods as described in Sepulveda and Aalbers (2018) prior to being imported into an Access database. The 30-d time series data from two MiniPAT deployments were analyzed independently of transmitted data from sPAT deployments, which provided 10-min resolution depth data for the final 5 days of each track. Daily minimum and maximum depth and temperature records were also summarized for all surviving individuals. Depth and temperature profiles were compared with tagging data from previously published studies on the bigeye thresher shark to assess regional differences (Nakano et al., 2003; Weng et al., 2004). The direction, net distance travelled and rate of horizontal movement were measured from tag deployment and pop-up locations for twelve of the tracks following protocols detailed in Heberer et al., (2010). Horizontal rates of movement for the two BETS (16P2130 & 16P2166) that did not survive the entire deployment duration were not used in the analyses. All records were classified as day or night based on the mean Pacific Standard Time (PST) of sunrise and sunset for each deployment at the initial tagging location using data from the Astronomical Applications Department of the U.S. Naval Observatory data services portal (http://aa.usno.navy.mil/data/index.php; Aalbers and Sepulveda, 2015). Twilight was defined as the periods between mean time of sunset and nautical twilight at dusk as well as from nautical twilight at dawn until mean time of sunrise (Aalbers and Sepulveda, 2015). Paired t-tests were used to test for differences in mean depth distribution during the day versus night periods for the two sharks with extended datasets (17P0215 & 17P0209). Mean day and night depths are presented with associated standard deviations (SD), and an alpha of <0.05 was used to infer significance.

2.4. Other Environmental Data

Water column temperature and dissolved oxygen profiles were periodically recorded during the tagging operations using an optical oxygen meter (RBR Concerto^3 Instrument, RBR Ltd., Ottawa, CA) and an associated time depth and temperature recorder (Cefas Technology Limited; Lowestoft, UK). Deployment casts were made proximal to BETS capture sites in the fall of 2018 to assess oxygen concentration at depth relative to diurnal movements.

3. Results

3.1. Survivorship

A total of 14 bigeye thresher sharks (147-190 cm FL) were tagged and released following capture on DSBG with fight times ranging from 15 to 171 min (mean = 72 ± 54 min; Table 1). Time from the initiation of haul back to release ranged from 8 to 20 min (mean=13.5 ± 4.5 min). One BETS was hooked in the pectoral fin with all remaining individuals (n=13) hooked in the mouth. Time depth recorders deployed on research sets showed that capture depths ranged from 295 to 315m. Two of the fourteen sharks died in this study, one died immediately after release and one died 6h later as a result of predation-induced mortality.

Two survivorship estimates are presented in this study; one in which the predation event is considered to have ensued as a result of the capture on DSBG (86% survivorship) and a second in which the predation induced mortality is removed from the analysis (92% survivorship). For the remaining individuals, post-release survivorship was further validated by horizontal displacement and consistent daily dive patterns (i.e. max depth <300 m and min depth >60 m) that resumed within 24h of release.

3.2. *Predation Induced Mortality*

BETS #16P2166 was preyed upon 6h after release on the night of September 04, 2018 (21:51 PST) at a depth of 26m. The shark was reported to be in good physical condition as it swam away from the cooperative fisher vessel. Archived temperature records fluctuated between 9.5 and 22.5°C during the initial 6-h of the track and abruptly stabilized at 21:51 PST. After this point the temperature gradually increased from 16.5 to 23.5 over the following 12-h period. Despite fluctuations in depth to 221 m (mid-water depth for this portion of the Santa Catalina Basin), temperature records remained between 23.5 and 26.3 throughout the remaining 5 d of the track.

3.3. Vertical Movements

All surviving BETS exhibited consistent vertical migrations surrounding dawn and dusk with peak vertical rates of movement during the twilight periods (Figure 3). Daily dives were consistently initiated between nautical twilight and sunrise to depths exceeding 300 m. Tagged BETS remained at depths ranging from 200-500 m for more than 99% of the daytime records with regular vertical ascents back into the upper mixed layer after sunset (Figure 3). Nighttime depths ranged from the surface to 184 m, with 80% of depth records above 100 m (Figure 4). During the twilight hours BETS exhibited a high level of vertical activity with movements spanning the water column from 13-397 m. Significant differences were observed between mean daytime, nighttime and twilight depth distributions. Mean daytime depth distributions ranged from 250-439 m between individuals, with mean twilight depths ranging from 154-214 m and mean nighttime depth distributions ranging from 20-106 m over the final five days of each track.

Mean daytime depth distribution based on the last five days of each track varied across pop-up locations. For instance, two tags (16P2422 and 17P0209) that popped up within 500 km of the southern Baja California coastline (Punta Magdelena, BCS, MX) revealed mean daytime depth distributions that were slightly shallower (250 ± 40 m and 289 ± 82 m, respectively) than those of the individuals that moved further offshore (BCS offshore corridor; n=8; range= 363-439 m). Similarly, the two tags (16P2401 and 16P2338) that popped up within the study area (SCB), exhibited mean daytime depths of 335 ± 55 m and 357 ± 29 m, depths within the target range of current DSBG activities and only slightly greater than the original capture depth (Figure 4).

3.3. Horizontal Movements

Tagged BETS moved up to 1362 km from the initial tagging site during the 30-day deployment period (mean = 1,009 ± 455 km; Figure 1). Eight of the BETS exhibited extensive movements (mean displacement rate of 37.8 ± 6.6 km day-1) in a S-SW direction (181-221° true heading) towards a corridor of offshore seamounts along southern Baja California, Mexico (22°-26°N and 118°-126°W; Figure 1). Two of the tagged individuals made extensive movements (mean displacement rate of 41.6 ± 6.6 km day-1) to the SE (162-171° true heading) before the tags popped up within 500 km of the Baja California Sur coastline, proximal to Punta Magdelena, BCS. Lastly, two tags popped up <150 km off of the southern California coastline (SCB) and within 185 km of the initial tag deployment site (mean displacement rate of 3.4 ± 3.6 km day^{-1}).

3.4. Temperature

Daytime temperatures at depth ranged from 6 to 10°C, while at night temperatures ranged from 18 to 25°C. For those sharks that travelled outside of the SCB (n=10) maximum temperature records (i.e., surface and mixed layer temperatures at night) increased over the course of the 30-day tracks, which is consistent with the general trend of increasing SST with decreasing latitude in this region. For the two individuals (17P0209 and 17P0215) with higher resolution time series data, daytime temperatures at depth averaged 8.7 ± 1.2°C and 7.5 ± 0.8°C, respectively, while nighttime temperatures averaged 17.4 ± 2.9°C and 18.2 ± 3.0°C.

4.Discussion

This study provides information on the post-release disposition of BETS captured with deep-set buoy gear (DSBG), a gear type targeting swordfish that is being trialed under exempted status off the California coast[1]. Results suggest a relatively high rate of post-release survival, with the vast majority of tagged BETS surviving the acute effects of capture (86% or 92%, depending on whether the predation induced mortality is considered in the estimate). Findings validate observer records and confirm that, when handled properly, BETS can tolerate the effects of DSBG capture. Regional movement and depth distribution data presented here are among the first available for this species and support findings from other areas of the equatorial Pacific and the Gulf of Mexico. Interestingly, BETS moved considerable horizontal distances throughout the 30-day deployments, with most sharks traveling to a region of the eastern Pacific off the coast of southern Baja California, Mexico. Although depth data suggest similarities in diurnal movements between BETS and swordfish (Sepulveda et al., 2010; Sepulveda and Aalbers, 2018), comparison of regional average daytime depths suggest that BETS may occupy a slightly deeper niche during the daytime.

4.1. Survivorship

---

[1] Accessed 12/25/2018; https://www.westcoast.fisheries.noaa.gov/fisheries/migratory_species/gear_research_permits.html

Although fishers and at sea fishery observer records had previously proposed that most BETS are alive and active upon release from DSBG operations (Sepulveda and Aalbers, 2018), this work confirms that the majority of BETS survive the acute effects of DSBG capture. This is in contrast to past studies which have shown that up to 50% of BETS are dead upon haul-back on pelagic longline gear (Coelho et al., 2012). Findings highlight differences in survivorship between DSBG, an artisanal and actively tended gear type (<8km horizontal footprint and <30 hooks set^{-1}; Sepulveda and Aalbers, 2018), and other more industrial swordfish gears that are left to soak overnight (i.e., deep and shallow set longline, >80km footprint, >1,000 hooks set^{-1}; Coelho et al., 2012). As discussed in past studies, it is likely that time on the line (overnight vs. a few hours) plays a major role in the ability of a fish to successfully recover from a capture event (Moyes et al., 2006; Heberer et al., 2010).

Although longer term survival was not tested in this study (>30 days), previous studies have shown that post-release mortality is highest in the immediate hours following release (Mason and Hunt, 1967; Jolly et al., 1979; Muoneke and Childress, 1994; Aalbers et al., 2004). To further support the use of a 30-day deployment metric and also assess the presence of moribund behavior, we examined daily depth distribution and compared these data to previous BETS studies (Moyes et al., 2006; Heberer et al., 2010). All 12 surviving sharks resumed similar diurnal dive patterns within 24h of deployment, which entailed a dawn descent, remaining at depth well below the thermocline all day and subsequently ascending into the mixed layer at dusk (Figure 3). These movements directly support those reported by both Nakano et al. (2003) and Weng et al. (2004), the only other movement studies for this species to date.

This work also aligns with previous post-release survivorship work on common thresher sharks (*Alopias vulpinus*), which examined disposition after similar fight times to those of this study (Heberer et al., 2010). However, in the previous common thresher work it was proposed that there may be a temporal threshold for time on the line and survival, as sharks with fight times >85 min were shown to have high post-release mortality rates. In contrast, the sharks in this study endured fight times up to 171 min and, surprisingly, the one mortality was not on the line for the longest duration (110 vs 171 min; Table 1). Although exercise fatigue and the accumulation of anaerobic metabolites have been shown to affect muscle performance and in some cases survival (Wood et al., 1983; Milligan et al., 1996; Kieffer, 2000; Skomal and Bernal., 2010), several factors may also contribute to the resilience and survival of BETS while on DSBG. First, BETS caught using DSBG are typically in water temperatures from 7 to 9°C (Figure 3), a range much colder than that documented for most post-release survivorship work. Colder temperatures can slow swimming muscle contraction rates and reduce anaerobic metabolite accumulation (Eddy et. al., 2016; Schlenker et al., 2016). Also, the BETS has been shown to have complex gills with the largest gill surface area documented for any elasmobranch species studied to date (Wootton et al., 2015). Respiratory specializations have been hypothesized to enable extended exposure to reduced oxygen concentrations at depth, and may also help facilitate recovery from exhaustive exercise.

Unlike previous studies on the common thresher shark, this work could not differentiate survival rates from different hooking locations among BETS that also appear to use their caudal fin to stun prey during feeding activity (Aalbers et al., 2010; Heberer et al., 2010; Sepulveda et al., 2015). Although most of the sharks tagged in this study were hooked in the mouth (13/14), research trials have documented that mouth, caudal and pectoral fin hook locations have all been reported among DSBG captured BETS (Sepulveda et al., 2014; Sepulveda and Aalbers, 2018). For the common thresher, caudal-hooking has been proposed to reduce the shark's ability to ram ventilate when on the line, a factor that has been proposed to impede respiration and likely contributes to an increase in post-release mortality (Heberer et al., 2010). However, over the course of DSBG development and gear trials, caudal hooking of BETS has decreased significantly, likely attributable to the shift from "J" hooks to the exclusive use of circle hooks (Sepulveda et al., 2014; Pers. Observation, C. Sepulveda). Circle hooks have been shown to reduce caudal-hooking rates of common thresher sharks in the southern California recreational fishery (Heberer et al., 2010; Sepulveda et al., 2015). Although hook location and hooking damage were not assessed independently in this study, the small number of sharks tagged and the low number of mortalities (two individuals) prevents speculation of trends related to hook location. Nonetheless, the one shark that died immediately following release was hooked in the corner of the mouth, a location that has not been associated with high mortality in the past common thresher work (Heberer et al., 2010; Sepulveda et al., 2015). However, from recent gear development and tagging work on swordfish, our group has occasionally observed circle hooks that initially penetrated the esophagus or soft tissue of the gut, but later embed in the jaw after significant tearing. (Pers. Comm. Mark Okihiro, California Department of Fish and Wildlife). Because we were not able to inspect the gut or esophageal region of tagged sharks, it is not possible to know if the hook position played a role in the mortality.

An additional factor that has been shown to influence post-release survival is dissolved oxygen (DO) concentration (Lee and Bergerson, 1996; Schlenker et al., 2016). Interestingly, BETS were captured at depths where DO concentrations were less than 2 mg L^{-1}, a level much lower than that of the upper mixed layer (50 m ~7.3 mg L^{-1}; Figure 5). Based on the typical position of strike detection buoys prior to haul back of BETS (Figure 2), it was evident that BETS tend to remain at depth while on the line in contrast to the behavior of swordfish and opah, *Lampris guttatus*, species that typically move towards the surface and enter into waters of higher DO concentration during the fight. Because of the low DO concentrations at depth, it was originally hypothesized that BETS survival would be compromised during extended fight times. However, from this work it is evident that BETS are resilient to prolonged exposure to low DO concentrations, levels that may be lethal to other pelagic species. Additional work is needed to fully understand how BETS tolerate continued exposure to reduced DO concentrations.

4.2 *Predation Induced Mortality*

BETS #16P2166 was classified as a predation event based on depth, temperature and light level data obtained from the sPAT archival record following physical recovery. The recovered tag provided access to the full data archive which revealed that the predation event occurred within the upper mixed layer at night only 6h after release. During the first hours of the track the archived temperature records resembled those of the other BETS tagged in this study (Figure 3), however, after 6h the temperature stabilized and then gradually increased. Subsequent temperature records showed that despite fluctuations in depth to 221 m, temperature records remained stable (23.5 to 26.3°C) throughout the remaining 5 d of the track period. The temperature range and depth data are consistent with the stomach temperatures (18.9–25.9°C) and vertical movements documented for lamnid sharks (Goldman, 1997; Sepulveda et al., 2004). Post-release predation by lamnid sharks has been previously documented in several tagging and post-release survivorship studies (Kerstetter et al., 2004; Marcek and Graves, 2014; Tracey et al., 2016; Goldsmith et al., 2017). Although BETS are not considered a common prey item of lamnids, foraging on sharks and rays has been documented for this group of large pelagic sharks (Fergusson et al., 2000).

Because the predation event occurred only 6h after release and at a depth that is within the range of normal behavior for BETS (based on this study and that of previous work, Nakano et al., 2003; Weng et al., 2004) the condition of the shark and the extent to which the shark had recovered from the capture event is unknown. BETS #16P2166 did not have an extended fight time nor was it hooked in a location that would likely increase the risk of mortality or predation. Although increased risk of predation has been documented for fatigued individuals following release from both commercial and recreational gear types (Skomal and Chase, 2002; Kerstetter and Graves, 2004; Tracey et al., 2016), it was not possible to determine if this predation event was directly related to the capture event, the presence of the tag, or possibly the tagging process (Goodyear 2017; Goldsmith et al. 2017).

4.3. Vertical Movements and Ecology

Previous accounts on the movements and ecology of BETS were inferred from gut contents studies and past tagging work from disparate regions of the Pacific and Gulf of Mexico (Nakano et al., 2003; Weng et al., 2004; Preti et al., 2008). Similar to past reports, this work has shown that BETS exhibit a marked diurnal dive pattern in which the entire daylight period is spent well below the thermocline contrasted by a nocturnal distribution within the upper mixed layer (Nakano et al., 2003; Weng et al., 2004; Figures 3. & 4.). Daytime depths were also proximal to the upper reaches of the oxygen minimum layer (OML), which has been shown to be relatively shallow off the coast of California (Bograd et al., 2008; Booth et al., 2014; Netburn and Koslow, 2015; Figure 5). Similar to swordfish, the timing of BETS ascents and descents also aligned with the timing of the vertical migrations of the DSL within the eastern Pacific (Cade and Benoit-Bird, 2015; Sepulveda and Aalbers, 2018; Sepulveda et al., 2010). In line with past studies, BETS daytime depth distribution closely mirrored that of the regional deep scattering layer (DSL; as observed aboard the R/V Malolo's sonar; Furuno CH 250, WA, USA). Collectively, these movements align with previous gut contents studies of the region which have shown BETS to be heavily reliant upon both DSL and epipelagic prey (Preti et al., 2008).

Despite differences in seasonality, bathymetry and oceanography between the two study sites, the average daytime depths of BETS in this study closely align with the ranges described for two BETS acoustically tracked off the eastern equatorial Pacific (Nakano et al., 2003). Although nocturnal movements from this study also approximated those of Nakano et al. (2003), average night depths were slightly shallower, likely an artifact of the relatively strong and shallow thermocline present off the SCB (Cairns and LaFond; 1966; Bograd et al., 2008).

4.4. Horizontal Movements

Although not commonly observed due to its diurnal depth distribution, the BETS seasonally inhabits the SCB during the summer and fall months (Hanan et al., 1993; Preti et al., 2008). Tags deployed in this study showed BETS to either remain proximal to the study area (n=2) or travel to a region off the coast of Southern Baja California (n=10) towards a series of offshore seamounts that have been highlighted as an important offshore corridor for white sharks (*Carcharodon carcharias*) (Domeier and Nasby-Lucas, 2008; Jorgenson et al., 2009; Figure1). Although regional affinity remains unknown, the prevalence of movements towards this area may prove important in understanding the ecology and migration patterns of this species. Initial movement data also support the highly migratory nature of BETS and provide insight into the different fisheries that this species may be subjected to over the course of a single season.

4.5. Temperature

As described by previous authors, BETS have been shown to display extreme temperature tolerance, capable of spending extended periods (>10h) within the warm surface layers at night and abruptly transitioning to a cold (<10°C) sub-thermocline existence during the entire day (>12h; This study; Nakano et al.,2003; Weng et al., 2004). This degree of thermal plasticity has been highlighted for several regionally endothermic species (i.e., tunas, lamnid sharks, swordfish), but less frequently described for active ectothermic species like the BETS (Carey et al., 1982; Carey and Robison 1981; reviewed by Bernal et al., 2009). Given that recent work has shown BETS to possess a similar red muscle (RM) distribution to other ectothermic fish species (Sepulveda et al.,2005; Patterson et al., 2011), internal temperatures track that of the surrounding water, which subjects the RM to a wide range of operating temperatures (7-25°C, this study). This degree of thermal fluctuation is unusual in fish and can be lethal for some species (Bernal et al., 2005). The BETS's capacity to endure a wide temperature range has recently been supported by *in-vitro* studies on isolated RM bundles, which show BETS can produce positive work over a much broader temperature range than other sympatric species (Stoehr, 2018). Future studies are needed to better understand how BETS tolerate extended exposure to disparate conditions, as well as the role of thermal tolerance in the ecology of this poorly known species.

4.6. Fisheries

Off the California coast, BETS are almost exclusively caught as an incidental species in fisheries directed towards swordfish and other highly migratory species (Hanan et al., 1993; Sepulveda et al., 2014; Sepulveda and Aalbers, 2018). Due to their relatively low value, fishers often release BETS, a scenario that has prompted efforts to assess post-release disposition and also identify if fishery operations can be modified to reduce interaction. Although the diel depth distribution of BETS in this study is very similar to that documented for swordfish off southern California (Sepulveda et al., 2010; Dewar et al., 2011); this work has identified a few subtle differences that may prove effective for reducing future interaction in CA deep-set fishery for swordfish. Based on data from two tagged BETS that remained within the SCB (Figure 4; yellow bars), the average daytime depth distribution in the SCB was slightly deeper (335 ± 55 m and 357 ± 29 m) than that of swordfish tagged in the same region (273 ± 11 m; Sepulveda et al., 2010). These preliminary data suggest that shallower hooks may be a way to further reduce fishery interaction. However, given potential seasonal and inter-annual variability, additional movement data is needed to fully assess the efficacy of such gear modifications. Further, given that this work has shown that BETS can survive the effects of DSBG capture, and because BETS can provide economic return to those that wish to retain them, mandated gear modifications to further avoid this species are likely not warranted at this time.

4.7. Summary

Documenting post-release disposition of DSBG caught BETS will allow managers to quantify fishery impacts and also better inform fishers on whether catch should be retained or discarded during daily operations. Understanding post-release disposition is a mandate of the

Magnuson-Stevens Act[2], the primary law governing marine fisheries management in U.S. federal waters, and continues to be a regional management priority. In addition, this work also has the potential to positively impact future domestic DSBG operations, as ecological ranking programs[3] set up to assess fishery impacts can now better evaluate the developing DSBG fishery.

Acknowledgements

Support for this work was provided by the National Oceanic and Atmospheric Administration Bycatch Reduction and Engineering Program (Award #NA16NMF4720371) as well as the Pew Charitable Trust. Additional support was provided by the National Science Foundation (IOS-1354593 and IOS-1354772) as well as The Nature Conservancy, George T. Pfleger Foundation, the Offield Family Foundation, Santa Monica Seafood, and the William H. and Mattie Wattis Harris Foundation. Special thanks are offered to cooperative fishers that assisted with tag deployments, especially Cpt. Donald Krebs and Cpt. Nathan Perez. We would also like to acknowledge Diego Bernal for his time and effort with the figures, Paul Tutunjian, Corey Chan, Thomas Fullam, Jeanine Sepulveda, Victoria Wintrode and Jennifer Thrikell.

---

[2] Accessed 12/25/2018; https://www.fisheries.noaa.gov/resource/document/magnuson-stevens-fishery-conservation-and-management-act

[3] Accessed 12/25/2018; https://www.fishwatch.gov/

References

Aalbers, S.A., Stutzer, G.M., and Drawbridge, M.A., 2004. The effects of catch-and-release angling on the growth and survival of juvenile white seabass captured on offset circle and J-type hooks. N. Am. J. Fish. Manage. 24, 793–800.

Aalbers, S.A., Bernal, D., and Sepulveda, C.A., 2010. The use of the caudal fin in the feeding ecology of the common thresher shark, *Alopias vulpinus*. J. Fish Biol. 76, 1863-1868.

Aalbers, S.A. and Sepulveda, C.A., 2015. Seasonal movement patterns and temperature profiles of adult white seabass (*Atractoscion nobilis*) off California. Fish. Bull. 113:1–14.

Bernal, D., Donley, J. M., Shadwick, R. E., and Syme, D. A., 2005. Mammal-like muscles power swimming in a cold-water shark. Nature. 437:7063, 1349-1352.

Bernal, D., Sepulveda, C., Musyl, M. and Brill, R., 2009. The eco-physiology of swimming and movement patterns of tunas, billfishes, and large pelagic sharks. Fish locomotion—an etho-ecological approach. Enfield Scientific Publishers, Enfield, NH, 437-483.

Booth J.A.T., Woodson C.B., Sutula M. , Micheli F., Weisberg S.B., Bograd S.J., Steele A., Schoen J., and Crowder L.B. 2014. Patterns and potential drivers of declining oxygen content along the southern California coast. Limnol. and Oceanogr. 59. doi: 10.4319/lo.2014.59.4.1127.

Bograd, S.J., Castro, C.G., Di Lorenzo, E., Palacios, D.M., Bailey, H., Gilly, W., and Chavez, F.P. 2008. Oxygen declines and the shoaling of the hypoxic boundary in the California Current. Geophys. Res. Letters, 35(L12607), 1–6. https://doi.org/10.1029/2008GL034185.

Cade, D.E. and Benoit-Bird, K.J., 2015. Depths, migration rates, and environmental associations of acoustic scattering layers in the Gulf of California. Deep Sea Res. Part I: Oceanogr. Res. Paps. 102, 78-89.

Cairns, J.L., and LaFond, E.O. 1966. Periodic motions of the seasonal thermocline along the southern California coast. J. Geophys. Res. 71, 3903–3915. doi:0.1029/JZ071i016p03903.

Carey, F.G., Kanwisher, J.W., Brazier, O., Gabrielson, G., Casey, J.G., and Pratt, Jr., H. L., 1982. Temperature and Activities of a White Shark, Carcharodon Carcharias. Copeia. 2, 254–260. Doi: 10.2307/1444603.

Carey F.G. and Robinson B.H., 1981. Daily patterns in the activities of swordfish, *Xiphias gladius*, observed by acoustic telemetry. Fish. Bull. 79, 277–292.

Chen, C.T., Liu, K.M., and Chang, Y.C., 1997. Reproductive biology of the bigeye thresher shark,*Alopias superciliosus* (Lowe, 1839) (Chondrichthyes: Alopiidae), in the northwestern Pacific. Ichthyol. Res. 44, 227. https://doi.org/10.1007/BF02678702.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G., and Santos, M.N., 2012. An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. Aquat. Living Resour. 25:4, 311-319. https://doi.org/10.1051/alr/2012030.

Dewar, H., Prince, E.D., Musyl, M.K., Brill, R.W., Sepulveda, C.A., Luo, J., Foley, D. Orbesen, E.S., Domeier, M.L., Nasby-Lucas, N., Snodgrass, D., Laurs, R.M., Hoolihan, J.P., Block, B.A., and McNaughton, L.M., 2011. Movements and behaviors of swordfish in the Atlantic and Pacific Oceans examined using pop-up satellite archival tags. Fish. Oceanogr. 20:3, 219-241.

Domeier, M. and Nasby-Lucas, N. 2008. Migration patterns of white sharks *Carcharodon carcharias* tagged at Guadalupe Island, Mexico, and identification of an eastern Pacific shared offshore foraging area. Mar. Ecol. Progr. Ser. 370, 221-237. 10.3354/meps07628.

Eddy, C., Brill, R., and Bernal, D., 2016. Rates of at-vessel mortality and post-release survival of pelagic sharks captured with tuna purse seines around drifting fish aggregating devices (FADs) in the equatorial eastern Pacific Ocean. Fish. Res. 174, 109-117. https://doi.org/10.1016/j.fishres.2015.09.008.

Fergusson, I.K., Compagno, L.J. & Marks, M.A., 2000. Predation by white sharks *Carcharodon carcharias* (Chondrichthyes: Lamnidae) upon chelonians, with new records from the Mediterranean Sea and a first record of the ocean sunfish Mola mola (Osteichthyes: Molidae) as stomach contents. Environ Biol Fishes 58: 447-453. https://doi.org/10.1023/A:1007639324360

Fernandez-Carvalho, J., Coelho, R., Erzini, K., and Santos, N.M., 2011. Age and growth of the bigeye thresher shark, *Alopias superciliosus*, from the pelagic longline fisheries in the tropical northeastern Atlantic Ocean, determined by vertebral band counts. Aquatic Living Resour. 24, 359–368.

Fernandez-Carvalho, J., Coelho, R., Erzini, K., and Santos, N.M., 2015. Modeling Age and Growth of the Bigeye Thresher (*Alopias supercilliosus*) in the Atlantic Ocean. Fish. Bull. 113, 468-481.

Goldman, K. J., 1997. Regulation of body temperature in the white shark, *Carcharadon Carcharias*. J. of Comp. Physiol. B. 167:6, 423-429. https://doi.org/10.1007/s003600050092.

Goldsmith, W.M., Scheld, A.M., Graves, J.E., 2017. Performance of a low-cost, solar-powered pop-up satellite archival tag for assessing post-release mortality of Atlantic bluefin tuna (*Thunnus thynnus*) caught in the US east coast light-tackle recreational fishery. Anim. Biotelemetry 5:29. https://doi.org/10.1186/s40317-017-0144-9.

Graves, J.E., Luckhurst, B.E., Prince, E.D., 2002. An evaluation of pop-up satellite tags for estimating postrelease survival of blue marlin (*Makaira nigricans*) from a recreational fishery. Fish. Bull. 100, 134–142.

Gruber, S., and Compagno, J.V., 1981. Taxonomic status and biology of the bigeye thresher, *Alopias superciliosus*. Fish. Bull..79.

Hanan, D.A., Holts, D.B., and Coan Jr., A.L., 1993. The California drift gill net fishery for sharks and swordfish during the seasons 1981-82 through 1990-1991. Calif. Fish and Game Bull. 175, 1-95.

Heberer, C., Aalbers, S.A., Bernal, D., Kohin, S., DiFiore, B., and Sepulveda, C.A., 2010. Insights into catch-and-release survivorship and stress induced blood biochemistry of common thresher sharks (*Alopias vulpinus*) captured in the southern California recreational fishery. Fish. Res. 106, 495–500.

Horodysky, A.Z., and Graves, J.E., 2005. Application of popup satellite archival tag technology to estimate postrelease survival of white marlin (*Tetrapturus albidus*) caught on circle and straight-shank (‘‘J’’) hooks in the western North Atlantic recreational fishery. Fish. Bull. 103, 84–96.

Jolley, J.W., and Irby, E.W., 1979. Survival of tagged and released Atlantic sailfish (*Istiophorus platypterus*: Istiophoridae) determined with acoustical telemetry. Bull. Mar. Sci. 29, 155-169.

Jorgensen, S.J., Reeb, C.A., Chapple, T.K., Anderson, S., Perle, C., Van Sommeran, S.R., Fritz-Cope, C., Brown, A.C., Klimley, A.P., Block, B.A., 2009. Philopatry and migration of Pacific white sharks. Proc. Biol. Sci./ The Royal Soc. 277, 679-688. doi: 10.1098/rspb.2009.1155.

Kieffer, K.D., 2000. Review: Limits to exhaustive exercise in fish. Comp. Biochem. & Phys. A. 126, 161–179.

Kerstetter, D.W., Graves, J.E., 2008. Postrelease survival of sailfish caught by commercial pelagic longline gear in the southern Gulf of Mexico. N. Am. J. of Fish. Manag. 28:5, 1578-1586.

Lee, W.C., and Bergersen, E.P., 1996. Influence of thermal and oxygen stratification on lake trout hooking mortality. N. Am. J. of Fish. Manag. 16:175-181.

Mason, J.W., and Hunt R.L., 1967. Mortality rates of deeply hooked rainbow trout. Prog. Fish-Cult. 29, 87-91.

Marcek, B.J., Graves, J.E., 2014. An estimate of post-release mortality of school-size Atlantic Bluefin Tuna *Thunnus thynnus* in the U.S. recreational troll fishery. N. Am. J. of Fish. Manag. 34, 602-608

Milligan C.L., 1996. Metabolic recovery from exhaustive exercise in rainbow trout. Comp. Biochem. Physiol. 113A, 51–60.

Moyes, C.D., Fragoso, N., Musyl, M.K., and Brill, R.W., 2006. Predicting post release survival in large pelagic fish. Trans. Amer. Fish. Soc. 135, 1389–1397.

Muoneke, M.I., and Childress, W.M., 1994. Hooking mortality: a review for recreational fisheries. Rev. Fish. Sci. 2, 123–156.

Nakano, H., Matsunaga, H., Okamoto, H. and Okazaki, M., 2003. Acoustic tracking of bigeye thresher shark *Alopias superciliosus* in the Eastern Pacific Ocean. Mar. Ecol. Prog. Ser. 265, 255-261.

Netburn, A.N., and Koslow, J.A., 2015. Dissolved oxygen as a constraint on daytime deep scattering layer depth in the southern California current ecosystem. Deep-Sea Res. Part I: Oceanogr. Res. Pap. 104, 149–158. https://doi.org/10.1016/j.dsr.2015.06.006.

Patterson, J.C., Sepulveda,, C.A. and Bernal, D., 2011. The vascular morphology and in vivo muscle temperatures of thresher sharks (Alopiidae). J. Morphol. 272, 1353-1364. doi:10.1002/jmor.10989.

Preti, A., Kohin, S., Dewar, H., Ramon, D., 2008. Feeding habits of the bigeye thresher (*Alopias superciliosus*) sampled from the California-based drift gillnet fishery. CalCOFI Reports. 49, 202-211.

Schlenker, L., Latour, R.J., Brill, R.W., and Graves, J.E., 2016. Physiological stress and post-release mortality of white marlin (*Kajikia albida*) caught in the United States recreational fishery. Conserv Physiol. 4:1. doi:10.1093/conphys/cov066.

Sepulveda, C.A., Heberer, C., Aalbers, S.A., Spear, N., Kinney, M., Bernal, D., and Kohin, S., 2015. Post-release survivorship studies on common thresher sharks (*Alopias vulpinus*) captured in the southern California recreational fishery. Fish. Res. 161, 102-108.

Sepulveda, C.A. and Aalbers S.A., 2018. Exempted testing of deep-set buoy gear and concurrent research trials on swordfish, *Xiphias gladius*, in the Southern California Bight. Mar. Fish. Rev. 80:2, 1-29. doi: https://doi.org/10.7755/MFR.80.2.2.

Sepulveda, C.A., Heberer, C., and Aalbers, S.A., 2014. Development and trial of deep-set buoy gear for swordfish, *Xiphias gladius*, in the Southern California Bight. Mar. Fish. Rev. 76:4, 28-36. doi: dx.doi.org/10.7755/MFR.76.4.2.

Sepulveda C.A., Wegner N.C., Bernal, D., Graham J.B., 2005. The red muscle morphology of the thresher sharks (family Alopiidae). J. Exp. Biol. 208, 4255–4261.

Sepulveda, C.A., Knight, A., Nasby-Lucas, N., Domeier, M.L., 2010. Fine-scale movements of the swordfish in the Southern California Bight. Fish. Oceanog. 19:4, 279-289.

Skomal, G., and Bernal, D., 2010. Physiological responses to stress in sharks, in: Carrier, J.C., Musick J.A., and Heithaus M.R. (Eds.), The Biology of Sharks and their Relatives II: Biodiversity, Adaptive Physiology, and Conservation. CRC Press, pp 459-490.

Skomal, G.B. and Chase, B.C., 2002. The physiological effects of angling on post-release survivorship in tunas, sharks, and marlin. American Fisheries Society Symposium. 135-138.

Stoehr, A., 2018. Morphological and Physiological Adaptations to Sustain Swimming in Deep-Diving High Performance Fishes. University of Mass. Dartmouth, Doctoral Thesis.

Tracey, S.R., Hartmann, K., Leef, M., McAllister, J., 2016. Capture-induced physiological stress and post release mortality for Southern bluefin tuna (*Thunnus maccoyii*) from a recreational fishery. Can. J. of Fish. and Aquat. Sci. 73:10, 1547-1556.

Weng, K. and Block, B., 2004. Diel vertical migration of the bigeye thresher shark (*Alopias superciliosus*), a species possessing orbital retia mirabilia. Fish. Bull. 102, 221-229.

Wood, C.M., Turner, J.D., Graham, M.S. 1983. Why do fish die after severe exercise? J. Fish Biol. 22, 189–201.

Wootton, T.P., Sepulveda, C.A., & Wegner, N.C., 2015. Gill morphometrics of the thresher sharks (genus Alopias): Correlation of gill dimensions with aerobic demand and environmental oxygen. J. of Morphol. 276, 589–600.

Figure Legends

Figure 1.

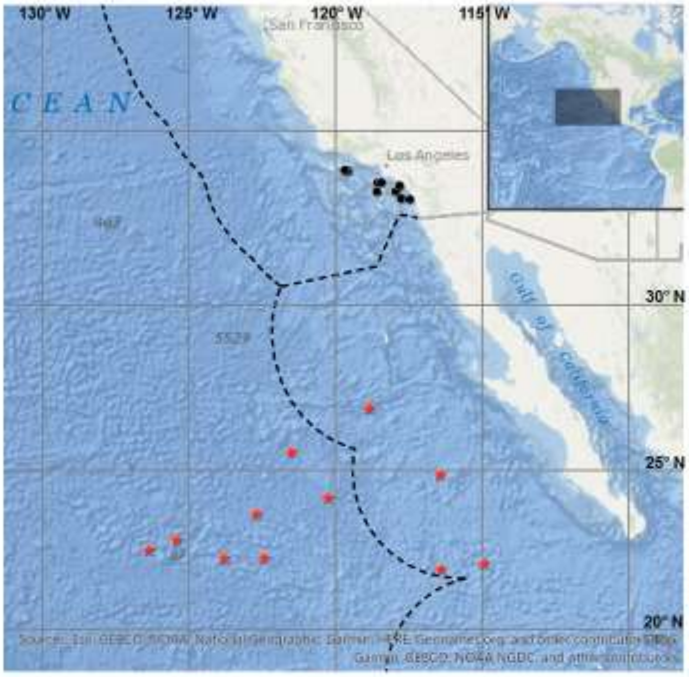

Figure 1: Map of the North Pacific Ocean created with ESRI ArcGIS PRO basemap (Accessed 5/30/2019; https://www.arcgis.com/home/item.html?id=5ae9e138a17842688b0b79283a4353f6), illustrating tag deployment (black circles) and pop-off (red stars) locations for twelve bigeye thresher sharks (*Alopias superciliosus*) which survived a 30-day period following capture on deep-set buoy gear (2016-2018).

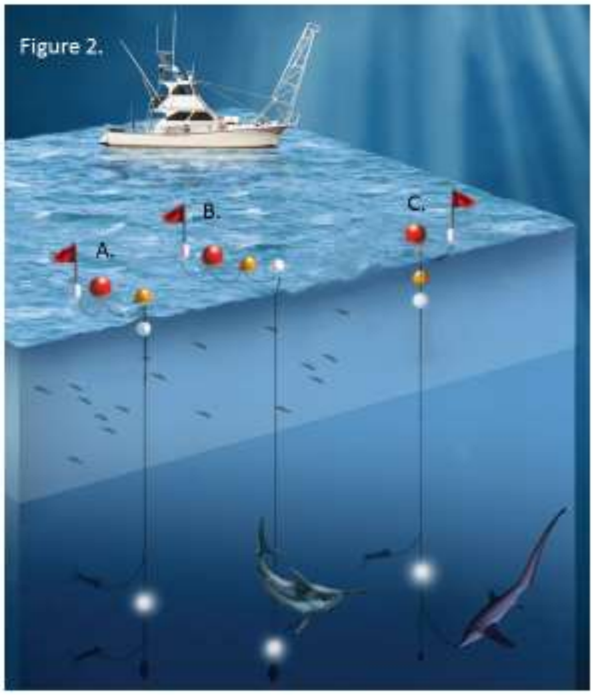

Figure 2: Deep-set buoy gear (DSBG) strike detection system illustrating the three surface buoy orientations observed during normal fishing conditions; A.) DSBG during active fishing operations in which two buoys are at the surface and one is submerged, B.) DSBG showing a typical swordfish strike, whereby the fish swims towards the surface creating slack in the vertical mainline which results in the surfacing of the white subsurface buoy, and C.) DSBG showing a typical BETS strike in which the shark swims downward pulling both strike indicator floats underwater. A light source is shown proximal to the baited hook.

Figure 3

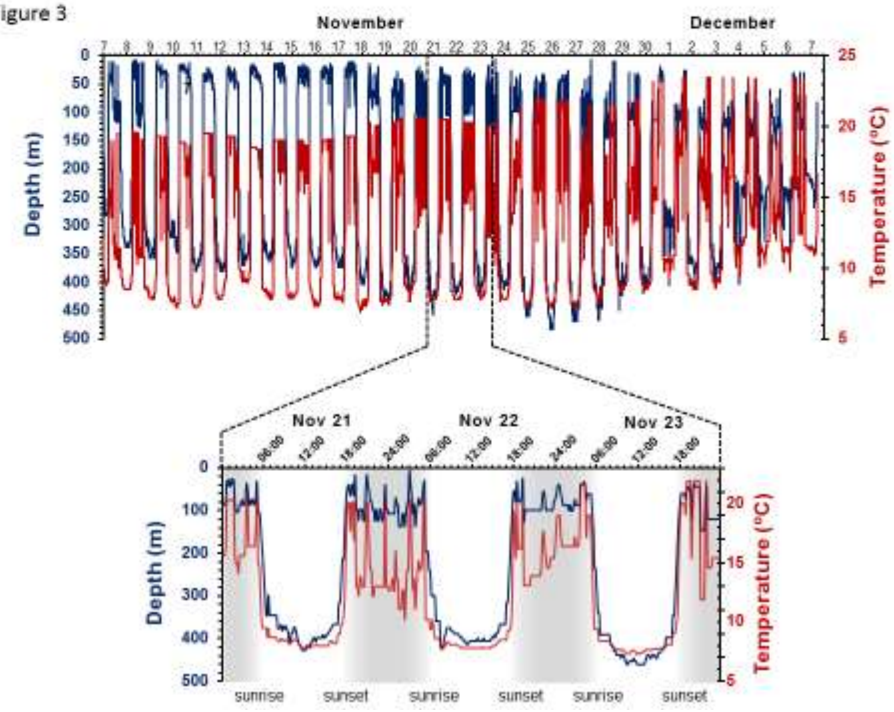

Figure 3. A plot showing the 30-day depth and temperature time-series data transmitted from bigeye thresher shark tag #17P0209 (upper); a 48-h period of the same track highlighting the consistent diurnal movement trends observed in this study (lower). Shaded portions of the inset represent night and temperature trace is shown in red and depth is in black.

Figure 4.

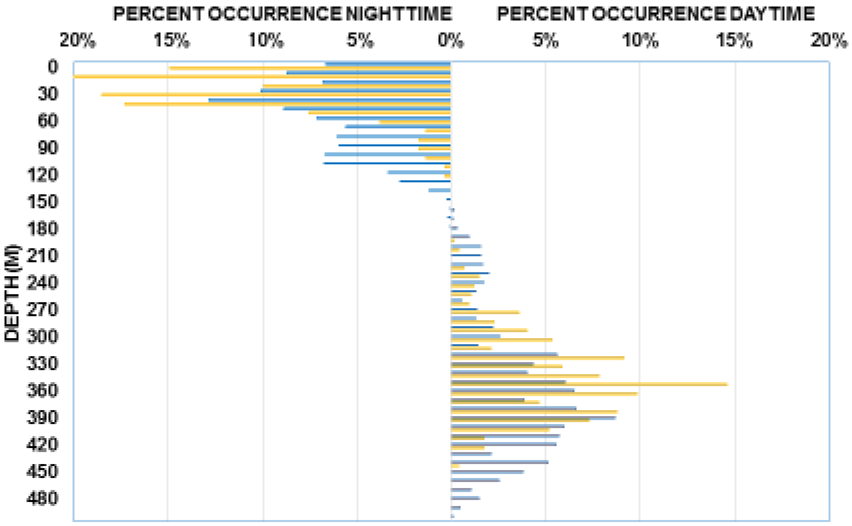

Figure 4. Daytime and nighttime depth data from the 10 bigeye thresher sharks (BETS) that travelled outside of the tagging area (data presented in 10 m depth bins; blue bars). Yellow bars represent the daily depth distribution of the two BETS that remained within the SCB throughout the duration of the deployment period.

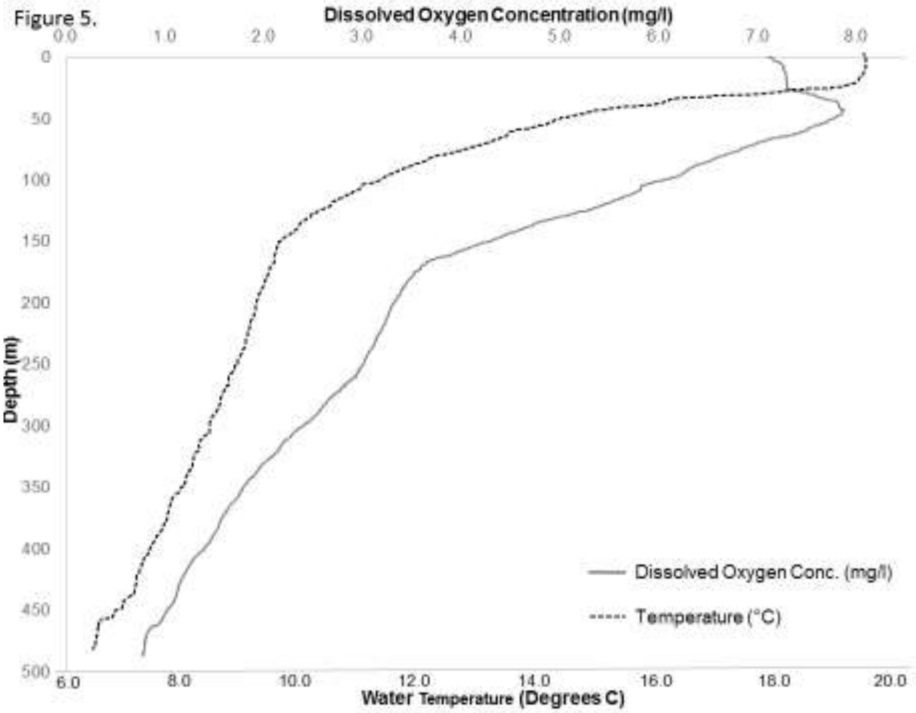

Figure 5: Dissolved oxygen concentration and temperature data from the surface to a depth of 500m; cast location was performed at one of the BETS tag deployment sites (November, 2018).

Table 1. Satellite tag deployment and pop-up data for fourteen bigeye thresher sharks tagged and released following capture on deep-set buoy gear off the coast of southern California.

PSAT #	PTT #	Vessel	Date	Location Lat/Lon	Fight time (min)	Pop-up	Pop-up lat/long	Distance (km)	ROM (km/day)	Heading	FL (cm)	Mortality
16P0969	164216	GoldCoast	10/24/16	33.547 -118.578	15	11/24/16	22.293 -123.821	1343	44.767	204	167	No
16P2130	171536	Malolo	8/4/17	33.239 -117.681	110	8/6/17	33.236 -117.684	1	0.033	195	175	Yes
17P0215	172429	GoldCoast	8/29/17	33.911 -119.701	>90*	9/29/17	25.601 -121.525	932	31.067	192	180	No
16P2422	171565	GoldCoast	10/17/17	33.301 -118.601	>90*	11/17/17	22.131 -114.938	1294	43.133	163	179	No
17P0209	172426	GoldCoast	11/5/17	33.556 -118.446	18	12/6/17	21.941 -116.415	1285	42.833	171	165	No
16P2338	171560	GoldCoast	8/8/18	33.943 -118.941	>90*	9/8/18	33.588 -118.419	25	0.833	160	178	No
17P0200	172422	GoldCoast	8/12/18	33.663 -118.681	>90*	9/12/18	23.913 -127.594	1362	45.401	221	178	No
16P2205	171533	Malolo	8/29/18	33.275 -117.795	171	9/29/18	22.161 -118.027	1247	41.567	181	147	No
16P2401	171538	Malolo	8/29/18	33.241 -117.763	139	9/30/18	31.671 -118.446	184	6.133	202	173	No
16P2402	171539	Malolo	8/29/18	33.265 -117.807	103	9/30/18	26.157 -120.475	812	27.067	198	190	No
16P2166	171548	GoldCoast	9/4/18	33.274 -118.125	35	9/11/18	33.083 -118.122	17	0.567	155	154	Predation
16P2336	171559	GoldCoast	9/16/18	33.433 -118.767	40	10/16/18	23.791 -126.101	1293	43.101	215	178	No
16P2335	171558	GoldCoast	9/25/18	33.454 -118.717	20	10/25/18	22.899 -121.794	1193	39.767	196	183	No
17P0204	172425	GoldCoast	9/23/18	33.461 -118.753	72	10/25/18	24.013 -123.591	1144	38.133	206	173	No

*Fight time estimate from cooperative fisher based on time between actively monitoring strike buoys