

# Short-term movement of a night shark (*Carcharhinus signatus*) in the western Caribbean with notes on the species' distribution and threats in the region

Ivy E. Baremore  · Francisco Polanco-Vásquez · Ana Hacohe-Domené · Daniel W. Castellanos · Rachel T. Graham

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**Abstract** Night sharks *Carcharhinus signatus* have suffered large declines in the western Atlantic Ocean, and while fishing mortality has slowed and populations stabilized in the northwestern Atlantic, they are still captured in high numbers as a targeted and bycatch species in the southern Atlantic Ocean. Considered one of the top five most vulnerable stocks in the Atlantic pelagic longline fishery, few records exist for this large-bodied species in the western Caribbean, and nothing is known about their movements or migration in the region. We found that mature night sharks occur in the western Caribbean from March through November and juveniles contribute to artisanal fisheries in the Guatemalan Caribbean. A seasonal aggregation of night sharks occurs at Glover's Reef Atoll, Belize, in the summer months, possibly for mating purposes, making this a potentially important site for the species. We also

document the first recapture of a tagged night shark in the western Caribbean, a subadult male that was tagged in northern Belize and recaptured after c. 60 days off Havana, Cuba. This recapture suggests that individuals undergo large scale movements, and coupled with known threats from fisheries, a regional approach for this species' management is favored.

**Keywords** Recapture · Belize · Guatemala · Cuba · Small scale fisheries · Management

## Introduction

Night sharks *Carcharhinus signatus* are a semi-oceanic and deep-water species that occur in the tropical and warm temperate waters of the western Atlantic Ocean from Delaware in the United States to southern Brazil (Ebert et al. 2013). The species was once reported as common in Cuban waters (Martinez 1947), but few records exist for the species in the western Caribbean (Kohler et al. 1998; Santana et al. 2006; Castro 2010; Chapman et al. 2011; Aguilar et al. 2014; Cortés et al. 2015). Listed as Vulnerable to extinction, mostly due to targeted fishing along the Brazilian seamounts and a seemingly steep decline in the US and Cuban fisheries historically ([redlist.org](http://redlist.org)), there is little known about the species in comparison to its congeners. Populations in the United States (US) appear to have stabilized, but captures of night sharks are now rarely reported in Cuban waters (Castro 2010), though it is unclear whether this is due to declines in the population or reduction in

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I. E. Baremore (✉) · D. W. Castellanos · R. T. Graham  
MarAlliance, PO Box 283, San Pedro Town, Belize  
Central America  
e-mail: ivy@maralliance.org

F. Polanco-Vásquez  
Universidad Rafael Landívar, Vista Hermosa III, Campus Central,  
Zona 16, Guatemala City, Guatemala

F. Polanco-Vásquez · A. Hacohe-Domené  
Fundacion Mundo Azul, Blvd. Rafael Landívar 10-05 Paseo  
Cayala Zona 16, Edificio D1 Oficina 212, Guatemala City,  
Guatemala

A. Hacohe-Domené  
Universidad del Valle de Guatemala, 18 Avenida 11-95 Zona 15,  
Guatemala City, Guatemala

fishing effort (Carlson et al. 2008). Due to a general lack of data and presumed decline, the species is listed as prohibited (no landings) in US waters as a precautionary approach to its management, but the species is captured as bycatch in pelagic longline fisheries elsewhere. An updated ecological risk assessment placed the night shark in the top five most vulnerable species in the Atlantic pelagic longline fisheries due to high capture rates and low productivity (Cortés et al. 2015).

Little is known about the population structure and movement patterns of night sharks, partly because of a lack of species-specific data throughout much of its range outside the US and Brazil. A recent study found moderate genetic diversity in night sharks in the western Atlantic Ocean, though those from the western South Atlantic Ocean had “among the lowest mtCR genetic diversity recorded in any *Carcharhinus* species” (Domingues et al. 2018). Two geographically overlapping mitochondrial lineages were detected, with significant population differentiation between the north and south Atlantic Ocean populations (Domingues et al. 2018). Night sharks sampled from Belize were not significantly different genetically from those US northern Atlantic or Venezuela, but were found to be distinct from those sampled in Brazil. Night sharks are known to aggregate at seamounts in Brazil, where they have historically been targeted due to their large pectoral fins, increasing value of the meat, and large abundance at predictable locations (Hazin et al. 1998; Santana and Lessa 2004). Of 191 animals tagged from 1962 to 93 along the US East Coast and Gulf of Mexico, 12 (6.3%) were recaptured: three were recaptured in Cuba and two in the Mexican Gulf of Mexico, while the other seven remained in US waters (Kohler et al. 1998). Night sharks have been reported as seasonal visitors by deep-sea fishers at Glover’s Reef Atoll in Belize (D. Castellanos pers. comm.), and 12 adults were previously captured by deep longlines from 2007 to 2011 (Chapman et al. 2011). The objectives of this study are to provide new information on the distribution, short term movement, and threats to night sharks in the western Caribbean.

## Materials and methods

A fishery-independent vertical longline survey was conducted in Belize and Honduras from 2016 to 2017 in waters from 150 to 400 m. Surveys along the northern

Belize Barrier Reef were conducted during all months except January and May, and opportunistically at the southern Belize Barrier Reef (October), Turneffe Atoll (April), Glover’s Reef Atoll (August, October), and Lighthouse Reef Atoll (May) in Belize, and Puerto Cortes (April) and Tela (September) in Honduras. Typical duration of surveys ranged from 2 to 6 consecutive days, when weather and sea conditions were favorable. Additional fishery-independent capture data from Chapman et al. (2011) were reported to the authors (D. Chapman, pers. comm.).

Vertical longlines were hand-deployed, and consisted of either a monofilament line terminating in 5 stainless steel 10/0 or 13/0 circle hooks, or a monofilament line terminating in a stainless steel leader and 4, 16/0 circle hooks baited with barracuda or bonito. A LAT1400 temperature depth recorder (TDR, Lotek Wireless, Inc.) was positioned just above the top hook, which measured temperature and pressure (dbar) every 15 s. Soak time averaged 30 min for the monofilament gear, and one hour for stainless steel gear, and gear was set between 04:00 and 22:00 h. Captured night sharks were measured for precaudal (PCL), fork (FL) and total lengths (TL, cm) in a curved line, sexed, tagged with an external roto tag, sampled (0.5 cm fin clip) for genetic analysis, and released.

To assess the abundance and distribution of night sharks in Belize and western Honduras, catch-per-unit-effort (CPUE) was calculated for vertical longline sets as the number of night sharks captured per hook hour, averaged by set:

$$CPUE = \frac{\text{Sharks}}{\text{hooks} * \text{hour}}$$

CPUE was calculated by location, as described above.

A specially-designed deep baited remote underwater video (BRUV) was deployed when weather conditions were favorable from 2016 to 2017 in Belize. The BRUV was set within visual range of the vertical longlines and soaked for an average of 90 min, and the bait was the same as that used for the longlines. A LAT 1400 TDR was positioned above the frame.

Periodically from February 2015 through July 2017 landings from artisanal fishers were recorded in El Quetzalito, Guatemala, by biologists or trained technicians (Hacohen-Domené et al. *In Review*). The Quetzalito-based fishery targets sharks during the

Lenten Season to meet increased demand for fresh and salted fish filet leading up to Semana Santa (Holy Week) (Graham 2007). Most fishers switch to lobster when the season opens after Easter (opening date is revised each year, but is normally March–June), though sharks are targeted and/or landed as bycatch opportunistically throughout the year, excluding the closed season (August–September). Fishers used either bottom longline or bottom gillnet to target sharks in waters >60 m. Landed sharks were identified, sexed, photographed, and measured for TL in a straight line, and fishers were briefly interviewed about gear types and depths of capture.

## Results

### Fishery-independent records

A total of 596 vertical longlines (2936 hooks, soak time 400 h) were set and retrieved in Belize and Honduras from 2016 to 2017 and 22 BRUVs were deployed in Belize in 2016 and 2017 (Fig. 1). Eight night sharks were captured, tagged, and released in Belize (Fig. 1, Table 1), and a ninth was sighted on the deep BRUV installation. Abundance of night sharks was highest at Glover's Reef Atoll, Belize during August, 2016 (CPUE = 0.038 night sharks per hook hour); overall CPUE during 2016–2017 was 0.003 night sharks per hook hour in northern Belize. Night sharks were only captured at Glover's Reef during August and at the southern tip of the atoll (CPUE = 0.028 overall). No night sharks were captured in southern Belize, Turneffe Atoll, Lighthouse Reef Atoll, or any sites in western Honduras; however, these surveys were not designed to target night sharks specifically, and were quite limited in their scope and therefore likely are not reflective of the true abundance of night sharks in the region. Eight mature male and two mature female night sharks reported by Chapman et al. (2011) were captured at Glover's Reef Atoll during May and June of 2008 and 2009; sizes ranged from 197 to 246 cm TL and capture depths ranged from 200 to 400 m.

Night sharks were captured at depths between 245 and 382 m (17.0–11.3 °C), and the night shark sighted on the BRUV was at 335 m (13.1 °C). Sharks were captured during daylight hours between 05:15 and 14:37 and the BRUV sighting occurred near dusk at 17:50. One shark

was captured on a size 10/0 hook, four on size 13/0, and three were captured on size 16/0 circle hooks.

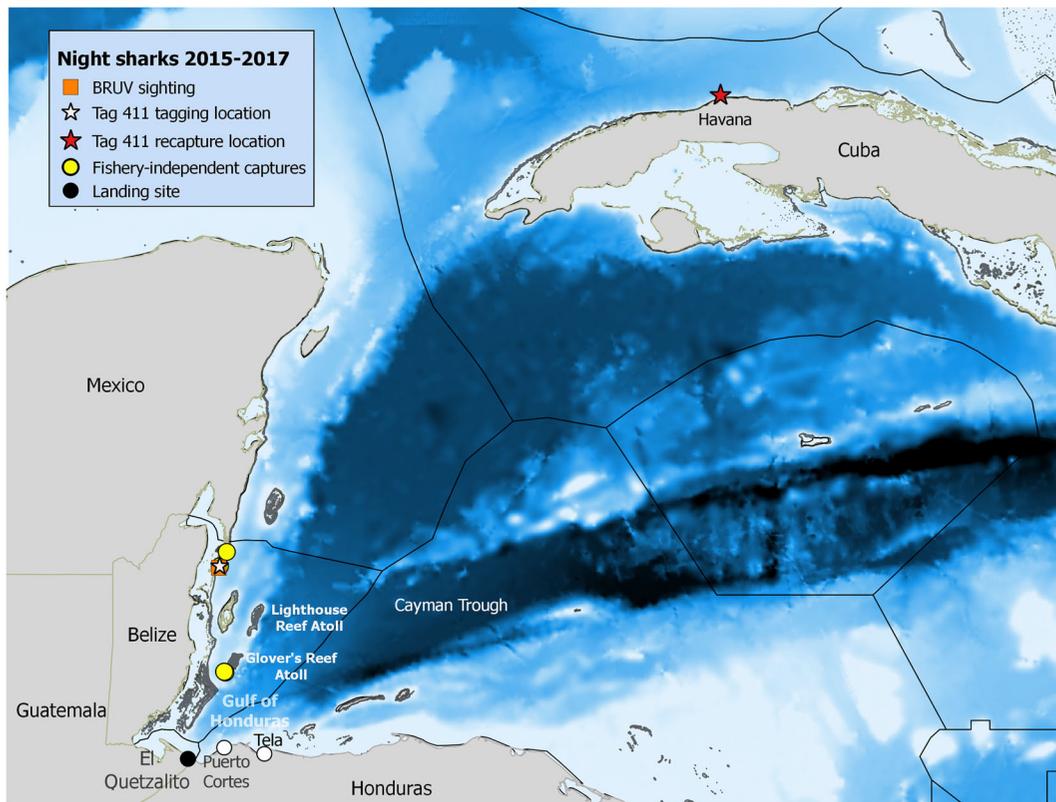
Five of the night sharks ( $n = 4$  females,  $n = 1$  male) were captured and tagged in August 2016 at the southern point of Glover's Reef Atoll (Fig. 1): the 170 cm FL (214 cm TL) male was determined to be mature based on clasper calcification, and the females were presumed mature due to size (170–194 cm FL/214–235 cm TL) (Hazin et al. 2000). Two females had fresh open wounds and bite marks near their pelvic fins and around the body (Fig. 2).

Two mature males were captured along the northern Belize Barrier Reef in July and September (160, 166 cm FL/204, 210 cm TL), and a third 160 cm FL (201 cm TL) male captured in July had partially-calcified claspers. The individual night shark recorded on the BRUV was sighted in November in northern Belize (Fig. 1), and appeared to be a mature male. A night shark was observed at the surface upon retrieval of the BRUV at 20:45, and was assumed to be the same individual sighted on camera.

The juvenile/subadult male tagged in northern Belize on July 29th, 2017 was subsequently captured by fishers one mile north of Havana, Cuba around the 22nd of September, 2017. Fishers reported that the shark was captured by gillnet and released, though the fishers kept the tag. The shortest path from tagging to recapture, assuming a northerly orientation of swimming, is approximately 1000 km in just under 60 d, or ~16 km/d.

### Landings

Landings data were recorded on a daily basis in El Quetzalito, Guatemala from January–July from 2015 to 2017 for a total of 92 d monitored. Sixteen night sharks were recorded from landings from February 2015 through July of 2017; seven were males (117–198 cm TL) and nine were females (100–242 cm TL) (Fig. 3, Table 1). The majority of night sharks landed (87%) were juveniles, with only two individuals over the reported size at maturity by sex (Hazin et al. 2000). The reported area of capture was in Guatemalan waters at depths of 60–90 m. Five sharks were captured using bottom gillnet and eleven sharks by bottom longline (Fig. 2). Overall, night sharks represented 3.2% of the total shark landings sampled in Quetzalito, Guatemala from 2015 to 2017 (Hacohen-Domené et al. [In Review](#)).



**Fig. 1** Capture locations and landing sites for night sharks in Belize, Guatemala, and Cuba 2015–2017. Shading represents increasing depth from light blue to dark and black lines delineate Economic Exclusive Zones (EEZ)

## Discussion and conclusions

This study provides some of the first locality records for night sharks in Belize and Guatemala, and the first recapture of a night shark tagged in the western Caribbean. Captures at Glover's Reef Atoll in Belize were predictable by location, depth, and time of the year, and the presence of open wounds on females are suggestive of mating scars; therefore, this may be a mating aggregation site for the species. Recent genetic analysis revealed that little gene flow occurs between the north and south Atlantic night shark populations separated by a minimum of 4150 km (Domingues et al. 2018). While night sharks sampled for genetics in Belize were distinct from those in Brazil, sample sizes were too low ( $n = 14$ ) for robust analyses and Belize samples contained both northern and southern Atlantic lineages (Domingues et al. 2018). It is likely that night sharks, like hammerhead sharks (*Sphyrna lewini*), travel long distances to form aggregations for mating or other purposes. Male-biased dispersal and female philopatry has been reported as a means of gene flow in large-bodied sharks

(Chapman et al. 2015), a pattern which was suggested for night sharks by Domingues et al. (2018), with authors hypothesizing two distinct breeding areas for the species. Aggregated night sharks captured in this study and previously (Chapman et al. 2011) at Glover's Reef Atoll from May–August were all mature, and large (>200 cm TL) males were present along the northern Belize Barrier Reef from June–November. The aggregation at Glover's Reef Atoll appears to occur at least from June–August, though the size of the aggregation is unknown. Though further genetic and fishery-independent abundance data throughout the Caribbean are needed, it is possible that this aggregation serves as an important route of gene flow from Venezuela to the rest of the northern Atlantic population.

The recapture of the subadult male in Cuba indicates at least a short-term northerly migration in late summer, but the species inhabits the MesoAmerican Region and its deep 200+ m waters year-round. The rapid movement observed for this individual and known depth-preferences (50–600 m) (Compagno 1984) of night sharks suggests that the individual likely used the

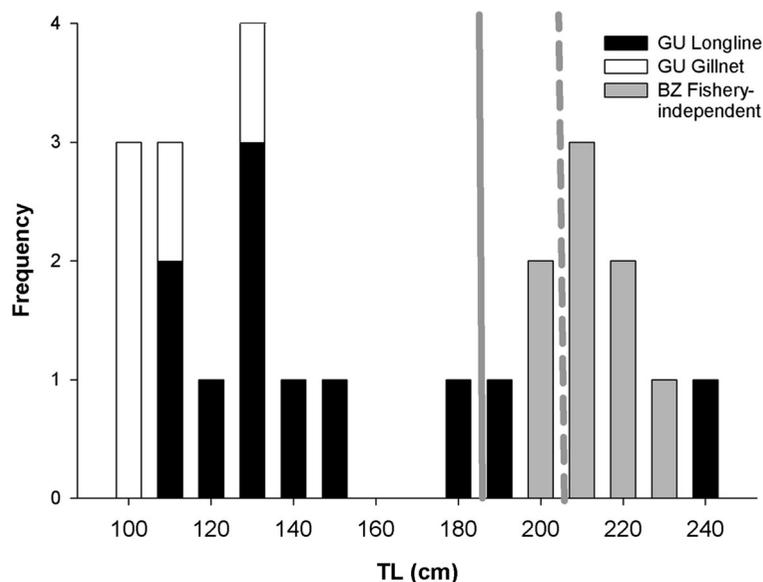
**Table 1** Dates of capture, locations, and fates of night sharks captured in Belize and Guatemala from 2015 to 2017. Asterisk denotes the same individual, captured and tagged and subsequently recaptured by fishers

Date	Sex	TL	Maturity State	Location	Gear	Fate
03-Feb-15	F	184	Juvenile	Quetzalito, GU	Longline	Landed
14-Mar-15	F	117	Juvenile	Quetzalito, GU	Longline	Landed
15-Mar-15	F	242	Mature	Quetzalito, GU	Longline	Landed
19-Dec-15	F	100	Juvenile	Quetzalito, GU	Gillnet	Landed
03-Mar-16	F	102	Juvenile	Quetzalito, GU	Gillnet	Landed
03-Mar-16	F	132	Juvenile	Quetzalito, GU	Longline	Landed
04-Mar-16	F	122	Juvenile	Quetzalito, GU	Longline	Landed
09-Mar-16	M	117	Juvenile	Quetzalito, GU	Longline	Landed
19-Mar-16	M	119	Juvenile	Quetzalito, GU	Gillnet	Landed
20-Mar-16	F	105	Juvenile	Quetzalito, GU	Gillnet	Landed
20-Mar-16	M	130	Juvenile	Quetzalito, GU	Gillnet	Landed
15-May-16	M	157	Juvenile	Quetzalito, GU	Longline	Landed
29-Jul-16	M	142	Juvenile	Quetzalito, GU	Longline	Landed
10-Feb-17	M	135	Juvenile	Quetzalito, GU	Longline	Landed
04-Apr-17	F	138	Juvenile	Quetzalito, GU	Longline	Landed
04-Apr-17	M	198	Mature	Quetzalito, GU	Longline	Landed
23-Aug-16	F	215	Mature	Glover's Reef, BZ	Vertical longline	Tagged, released
23-Aug-16	F	226	Mature	Glover's Reef, BZ	Vertical longline	Tagged, released
23-Aug-16	M	214	Mature	Glover's Reef, BZ	Vertical longline	Tagged, released
25-Aug-16	F	222	Mature	Glover's Reef, BZ	Vertical longline	Tagged, released
25-Aug-16	F	235	Mature	Glover's Reef, BZ	Vertical longline	Tagged, released
19-Sep-16	M	204	Mature	Northern Belize	Vertical longline	Tagged, released
29-Jul-17	M	201	Subadult	Northern Belize	Vertical longline	Tagged, released*
29-Jul-17	M	210	Mature	Northern Belize	Vertical longline	Tagged, released
15-Nov-16	M	~210	Mature	Northern Belize	BRUV	Sighted
22-Sept-17	M	201	Subadult	Havana, Cuba	Gillnet	Recaptured*

**Fig. 2** Photo showing the abdominal bite marks near the pelvic fins of a mature female tagged and released at Glover's Reef Atoll, Belize in August, 2016



**Fig. 3** Length-frequency for sharks tagged and released in Belize (BZ, grey bars) and landed in Guatemala (GU, black and white bars). The solid line represents the estimated size at maturity for males and the dashed line for females based on size (females) or clasper calcification (males) (Hazin et al. 2000)



bathymetry contours and northerly Caribbean current to navigate along the northern MesoAmerican Barrier Reef and across to the Straights of Florida above Cuba, similar to other sharks species that aggregate at discrete locations after large-scale migrations (Klimley 1993; Copping et al. 2018). Night sharks previously tagged in US waters appeared to remain in the northwestern Atlantic Ocean up to 12.9 years after tagging (Kohler et al. 1998), but the scale of the north-south migration of the species and populations is unknown. The maximum distance travelled by night sharks tagged in the northwestern Atlantic Ocean was 2668 km.

Sharks landed in Quetzalito, Guatemala are consumed locally as fresh filet, and are also transported and sold to larger markets in the country as dried salted fish filet (A. Hacothen-Domené pers. obs.). Though night sharks represented a relatively small proportion of overall landings sampled (3.2%), most night sharks landed had not reached sexual maturity. These results are likely representative of the overall fishery during this time period, as a trained biologist or resident technician recorded data during most of the landings. Fishers reported the fishing grounds were in Guatemalan waters, but the EEZ of Guatemala in the Caribbean does not include extensive deep fishing grounds, and the presence of many deep-sea shark species in the landings (Hacothen-Domené et al. 2016; Hacothen-Domené et al. 2017; Polanco-Vásquez et al. 2017; Hacothen-Domené et al. *In Review*) suggests that fishing of geographically-constrained shared stocks occurs. Previous community

work with the fishers also indicates that the primary fishing grounds are in the greater Gulf of Honduras, and that transboundary fishing in both Belizean and Honduran waters regularly takes place (Graham 2007). As the reported capture depths were relatively shallow and the fishers generally set gear in the evening, captures likely occurred at night, when night sharks are known to migrate to shallower depths.

Glover's Reef Atoll is a multi-use zoned Marine Reserve, with much of the deeper waters accessible to deep artisanal fisheries (> 150 m) inside the boundaries of the reserve; however, transboundary fishing, especially at night, has been reported. Although deep-sea sharks are not regularly targeted by Belizean deep-water fishers, fishers from Guatemala and Honduras target deep sea sharks using bottom longlines, vertical longlines, gillnets, and trammel nets. The demand for shark meat has increased in recent years and export of coastal and reef-associated shark and ray meat, especially during the Lenten season, has reached critical levels for many species (Graham 2007). Predictable aggregations of relatively long-lived species, particularly during times of reproductive importance, are especially susceptible to overfishing, even from small scale, artisanal fisheries (Graham et al. 2008, 2009; Sadovy de Mitcheson et al. 2013). The aggregation at Glover's Reef Atoll is also known by transboundary fishers from Honduras (I. Baremore pers. obs.), and is accessible by fishers from Guatemala and Honduras in under two hours' travel time. Though not traditionally targeted by

Belizean fishers, night sharks have recently begun to appear in landings data, indicative of the continued expansion of Belize's fisheries into deeper waters as coastal resources decline (National Shark Working Group meeting minutes, June 2017). A time-area closure from July–August of the seasonal night shark aggregation at Glover's Reef Atoll is recommended for a precautionary approach to management of the species in the region that would dovetail with the seasonal shark closure in Belize (September–October annually). Additionally, continued monitoring of the landings sites in Guatemala will help to determine the scope and trajectory of the fishery. The Western Caribbean faces the region's deepest trench, with discoveries made yearly (Hacohen-Domené et al. 2016; Hacohen-Domené et al. 2017; Polanco-Vásquez et al. 2017; Daly-Engel et al. 2018), and many more insights on the region's deep water sharks and their migrations are anticipated.

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