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An Unusual Capture of the Bluntnose Sixgill Shark, *Hexanchus griseus* on a Pelagic Longline in the Hawaiian Longline Fishery with Comments on the Worldwide Genetic Population Structure

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On 1 May 2016, a large, dark female shark (270 cm TL, 90.5 kg), with green eyes and six gill slits was captured in the Hawaiian longline fishery region (1900 km north east of the Big Island of Hawai'i) at a bottom depth of over 3000 m. A longline for bigeye tuna (*Thunnus obesus*) was set 30 Apr 2016 at 0833, and based on the hook number, the depth of capture was estimated between 100 and 200 m. Retrieval started the same day at 1748 and was completed at 0508 (1 May 2016). Based on the unusual nature of the specimen, the shark was retained and frozen onboard ship. The frozen shark was evaluated on 22 Jul 2016 for 60 morphological parameters plus teeth shape and row number. There were no visible stomach or intestinal food contents, no follicles present in the ovary, and the uterus appeared thread-like. The shark was clearly an immature female. A portion of the lower jaw and skin flank tissue was deposited in the Bernice P. Bishop Museum accession number BPBM 41330. Muscle tissue was removed for later DNA species verification, and photographs were taken (Figure 1). Based on the six gill slits, a single dorsal fin origin posterior to the pelvic fin base, and six rows of lower jaw comb-shape teeth, the specimen was identified as *Hexanchus griseus* the bluntnose sixgill shark (Compagno 1984; Ebert *et al*. 2013a).

The bluntnose sixgill shark (BSS), *Hexanchus griseus* (Bonnaterre, 1788) has been reported worldwide from the Atlantic, Indian, and Pacific oceans, and the Black and Mediterranean seas from the surface to 2500 m (Compagno 1984; Kabasakal 2004; Ebert *et al*. 2013b). This species is described as demersal, occurring on the continental shelves, slopes, seamounts, and submarine ridges (Compagno 2002; Barnett *et al*. 2012). It typically occurs in shallow, cold temperate water and inhabits deeper depths in subtropical and tropical waters. It was suggested that the BSS moved into the subtropics and tropics via isothermic submergence (Hubbs 1952).

Figure 1. Photographs of the Hawai‘i *Hexanchus griseus* frozen specimen: **A**. dorsal body length of female 270 cm TL. **B**. horizontal view of the head region. **C**. distinctive comb-shaped lower-jaw tooth pattern.

In the Hawaiian Archipelago, the BSS has been documented from Hancock Seamount to the island of Hawai‘i (Humphreys *et al*. 1984; Chave & Malahoff 1998). On O‘ahu’s southwestern coastline, 20-BSS (273–378 cm TL) were captured in shark control programs from 1959 to 1969, on bottom longline sets at depths of 110–366 m (Crow *et al*. 1996). In the 1967–1969 control program, BSS were typically captured at bottom depths of 330–366 m, with eight sharks captured on 105 hooks (Crow *et al*. 1996). Submersible observations of BSS around the main Hawaiian Islands have been at depths of 500 to 1440 m (Chave & Jones 1991; Chave & Mundy 1994), and free vehicle cameras have recorded BSS off Lisianski at 500 m and NW O‘ahu at 1000 m (Yeh & Drazen 2009). Recent satellite telemetry tracks of four BSS (266–333 cm TL) in Hawai‘i revealed a median daytime depth of 614 m and a median nighttime depth of 292 m (Comfort & Weng 2014). Generally, these sharks dove abruptly at dawn and remained deeper during

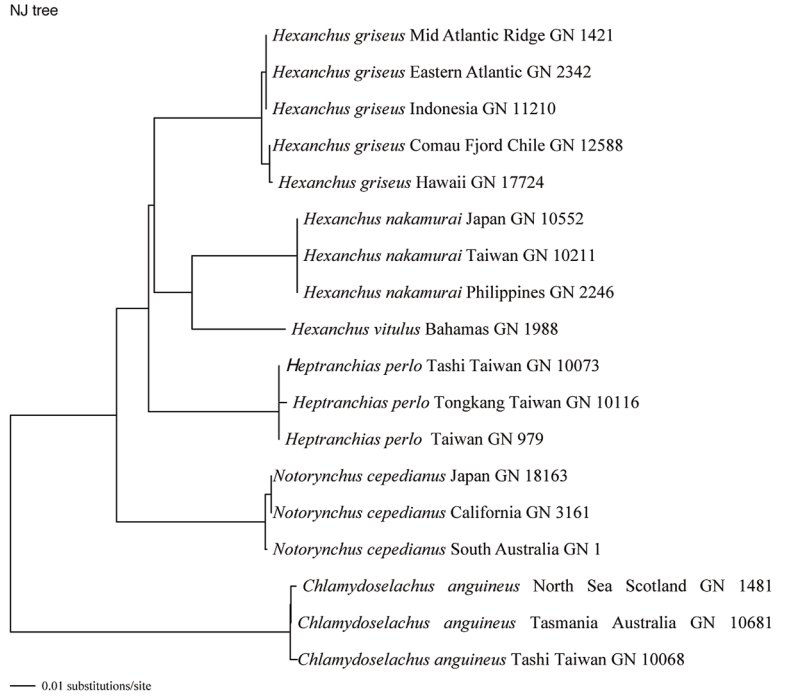

Figure 2. Updated Hexanchiformes phylogenetic tree for specimens of *Hexanchus griseus* in the Chondrichthyan Tree of Life database utilizing the NADH2 gene (www. sharksrays.org).

the day, with daytime activity rates at 1.3 m/min and nighttime rates at 2.2 m/min (Comfort & Weng 2014). The depth range of BSS in Hawaiian waters is typically below the thermocline, 100–400 m (Chave & Mundy 1994; Crow *et al*. 1996), at a maximum water temperature range of 5.4–20.6 °C, and generally below 16 °C (Comfort & Weng 2014). In Hawai‘i, the BSS is present within and outside the oxygen minimum zone (OMZ) (Yeh & Drazen 2009), a zone at bathyal depth ranges of 200–1000 m and with oxygen concentrations of <1 mg/L (Levin 2003). The OMZ is created through biochemical oxygen consumption with limited water circulation (Wyrtki 1962). In Hawai‘i, faunal species richness decreases at about 500–1000 m within the OMZ (Yeh & Drazen 2009). Immature BSS in Hawai‘i occur in the OMZ during daytime hours and ascend into the thermocline during the night (Comfort & Weng 2014).

Age at maturity, and detailed reproductive biology such as the reproductive cycle are largely unknown. The BSS reaches maturity at a fairly large size, with males at 300 to 315 cm TL (Crow *et al*. 1996; Capape *et al*. 2004; Barnett *et al*. 2012) and females at 400 to 420 cm TL (Capape *et al*. 2004; Barnett *et al*. 2012). Size at birth worldwide ranges from 56–74 cm TL (Capape *et al*. 2004; Ebert *et al*. 2013b) with a large range of embryos at 47–108 (Ebert *et al*. 2013b).

This is the first longline fishery report of BSS captured in the Hawaiian Islands. Worldwide longline captures of the BSS on pelagic longlines are rare and have been reported from off southern Brazil at depths of 60–120 m (Amorim *et al*. 1998), in Italian longline fisheries (Natale 1998), and the Venezuelan longline fishery in 1994–2000 caught four BSS that ranged in size from 97–119 cm TL (Arocha *et al*. 2002).

In order to ensure correct species identification with the challenges of small sample sizes, ontogenetic changes in morphology, and cryptic speciation, a small sample of dorsal flank muscle tissue was removed from the Hawai‘i BSS specimen. The tissue was sent to the College of Charleston for mitochondrial (mt) DNA isolation and sequencing. The mtDNA sequence was referenced against the Chondrichthyan Tree of Life—a genetic database that uses DNA sequences of the NADH2 gene to verify species identification and provide a window into population boundaries of sharks and rays (Naylor *et al*. 2012). The NADH2 sequence is a fast-evolving protein-coding gene that can distinguish between closely related species, cryptic species, and geographic variants and should be used with morphometric, meristic and voucher specimen retention (Naylor *et al*. 2012). The BSS database contains samples from the mid Atlantic ridge, eastern Atlantic, Indonesia, Comau Fjord (Chile), and Hawai‘i (Figure 2). The Hawai‘i sequences differ from Atlantic and Indian oceans’ BSS by two base pairs or less and are about 1 to 3% different worldwide. The sequences from the eastern Pacific, Chilean and central Pacific Hawai‘i are virtually identical. The sequences currently in the database reveal one BSS worldwide species.

CONSERVATION

Based on the large size at first reproduction and the assumption that BSS is not capable of sustaining sport or commercial fishing, the International Union for Conservation of Nature lists this shark as near threatened, globally (Camhi *et al*. 2009). In Hawai‘i, with the absence of sport or commercial fishing at the primary demersal population depth, the BSS remains fairly abundant. However, any habitat alteration relating to deep sea mining or fishing changes in Hawaiian waters could rapidly alter the population as is reported for sharks globally (Worm *et al*. 2013). A bottom longline fishery on Hancock Seamount for the pelagic armorhead (*Pseudopentaceros wheeleri)* resulted in a large bycatch of the dogfish shark *Squalus cf. mitsukurii* (Wilson & Seki 1994). The fishery had an estimated 50% decline in catch rate from 1985–1988 for this squalid species (Wilson & Seki 1994). Currently, we know very little about the population structure of deep-sea sharks in Hawai‘i making it hard to provide any advice for potential management.

CONCLUSIONS

This is the first report of a BSS from the Hawai‘i longline observer program since the program’s inception in 1994. Based on 97–270 cm TL size of specimens captured worldwide on pelagic longlines (Arocha *et al*. 2002; this report), immature specimens appear to utilize the pelagic environment to feed and possibly disperse. The satellite telemetry data reveal a more vagile species in the subtropics than was originally thought based on somewhat sluggish movements around video bait stations (Comfort & Weng 2012). The genetic sequence database supports a worldwide population in the Atlantic, Indian, and Pacific oceans that retains connectivity by immature individuals actively utilizing the pelagic zone and adults utilizing demersal habitats at seamounts, islands, and atolls that can serve

as either stepping stones for dispersal or "oases" for sustained biodiversity (Crow *et al*. 1996; Kvile *et al*. 2014). The BSS is a worldwide, large, active predator that is common in Hawai'i benthic habitats but is potentially vulnerable to habitat destruction or fishing pressure.

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