Relative Abundance of Sixgill Sharks (Hexanchus griseus) in Elliott Bay, Seattle, Washington

Denise Griffing
Seattle Aquarium, d.griffing@seattleaquarium.org

Shawn Larson
Seattle Aquarium, s.larson@seattleaquarium.org

Jeff Christiansen
Seattle Aquarium, j.christiansen@seattleaquarium.org

Joel Hollander
Seattle Aquarium, j.hollander@seattleaquarium.org

Tim Carpenter
Seattle Aquarium, t.carpenter@seattleaquarium.org

Follow this and additional works at: https://cedar.wwu.edu/ssec

Part of the Fresh Water Studies Commons, Marine Biology Commons, and the Natural Resources and Conservation Commons

Griffing, Denise; Larson, Shawn; Christiansen, Jeff; Hollander, Joel; and Carpenter, Tim, 'Relative Abundance of Sixgill Sharks (Hexanchus griseus) in Elliott Bay, Seattle, Washington' (2017). Salish Sea Ecosystem Conference. 14.
https://cedar.wwu.edu/ssec/2016ssec/species_food_webs/14

This Event is brought to you for free and open access by the Conferences and Events at Western CEDAR. It has been accepted for inclusion in Salish Sea Ecosystem Conference by an authorized administrator of Western CEDAR. For more information, please contact westerncedar@wwu.edu.
THE SEATTLE AQUARIUM

Overview

The Seattle Aquarium has been studying wild blunt-nosed sixgill sharks (Hexanchus griseus) in Puget Sound in partnership with the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), and the Washington Department of Fish and Wildlife (WDFW) since 2003. The sixgill shark is a large predator that is widely distributed in the Salish Sea (Pietzsch and Orr 2015). The data collected suggests that sixgill sharks may utilize Puget Sound as a spawning and nursery habitat. Adult females have been documented in Puget Sound in the process of giving birth or immediately afterward, and the vast majority of the documented larvae (less than 200 animals) were adult juveniles. These six-gill sharks have relatively small home ranges (about 10 km) that shift between adjacent summer and winter areas. In addition, we learned that sub-adult sixgills are found in groups made up primarily of related individuals—full or half siblings (Table 1). These groups of related sixgills may remain together in small home ranges until they reach a size or age at which they begin to migrate into their adult habitat of the open ocean. The processes that drive the animals’ movements while in Puget Sound and the triggers that stimulate outmigrations are unknown.

Materials and methods

The Seattle Aquarium is situated on Piers 59 and 60 in the middle of Seattle’s waterfront. The Aquarium conducted periodic research events (2003–2005) where we placed bait, lights, cameras and divers (within a protected contact cage) adjacent to Pier 59 to video-document, visually tag (movement and abundance analyses) and biopsy sharks (genetic analysis) at the research site. Research was stopped during 2005–2007 due to facility renovations but resumed for the period 2008–2015 (Griffing et al. 2014).

Tagging: When free-swimming sharks came within range, divers used pole spears to insert visual marker tags in the sharks’ dorsal musculature (n=45) or obtain 2–3 mm tissue samples for genetic analysis (n=29) during 2003–2005 (Griffing et al. 2014).

Genetic analysis: Tissue samples were collected from sixgill sharks at the Seattle Aquarium research site from 2003 to 2005 (n=29) and from sharks collected during trawls and longline sets conducted by WDFW and NOAA from 2003 to 2007 (n=295). DNA was extracted from the tissue samples using the DNeasy Blood and Tissue Kit. Microsatellites were amplified and screened using a GeneAmp PCR 9600 thermal-cycler. PCR products were analyzed on an Applied Biosystems 310 single-capillary system or 3100 ten-capillary system in Genescan mode. Relatedness estimates were made using MELATE, COLONY and KINGROUP software (Larson et al. 2010; Kalinowski et al. 2006).

Video analysis: Abundance data is presented from 50 research events representing 96 nights of observation with 12 hours of video footage recorded on between one and five fixed cameras each night. Footage was analyzed to determine presence/absence and sex and identify individual animals through tag ID or unique morphological characteristics.

Results and findings

Reared pregnant females were reported in Puget Sound (Hammersley Inlet: Dunegan 2007; Larson et al. 2010, the Salish Sea (G. Bargmann pers comm 1994; Comox Valley Record 2011) and the outer coast of Vancouver Island (Hamilton 2011). Analysis of the genetic relationship between the Hammersley Inlet female and 71 of her near-term pups suggested a polyandrous mating system with at least six males contributing to her offspring (Larson et al. 2010).

During local surveys, based on total length, all sixgills were sub-adult in size. At birth, sixgills are 60–70 cm in length; males reach maturity at 310 cm and females at 420 cm (Castro 1983; Erbe 1986; Pietzsch and Orr 2015). Williams et al. 2010 reported total lengths of 159–296 cm for males and 175–313 cm for females from Puget Sound (2006–2008). Andrews et al. 2010 reported total lengths of 109–293 cm for Puget Sound sixgills (2005–2006). The International Pacific Halibut Commission (IPHC; unpublished data) reported total lengths of 86–250 cm for sixgills in Puget Sound (n=18) and Hood Canal (n=1) in 2011.

Genotypic data using 10 polymorphic microsatellites were used to describe sixgill shark genetic diversity, clade identity and mating strategy (Larson et al. 2010). Diversity within sixgills was found to be low-moderate with an average observed heterozygosity of 0.45, an average expected heterozygosity of 0.61 and an average of 12 alleles within microsatellite loci. Genetic software programs suggested one intermixing population.

The proportion of individuals that were full or half siblings was high among sharks sampled at the same time and place (range 0.65–0.87) but not among those individuals related to each other between sets was much lower (range 0.16–0.23 total related) (Larson et al. 2010). Based on acoustic monitoring, these groups of related sixgills may remain together in relatively small home ranges until they begin to migrate into the open ocean (Andrews et al. 2010). NOAA reported that acoustically tagged sixgills were largely sedentary with a 62 percent probability of detecting the same sixgill at the same location on a subsequent date with some seasonal north/ south movements of approximately 7–25 km (Andrews et al. 2010). It is possible that sixgills are acoustically tagged sixgills leaving Puget Sound. These sixgills tagged in Puget Sound were detected along the Pacific coast as far south as Point Reyes, CA and as far north as Queen Charlotte Strait, BC. Calculated total length was a significant predictor of females leaving Puget Sound but not for males. Three females who had left Puget Sound subsequently returned, but then left the following year (Andrews et al. 2010).

For 2008–2015, local abundance was much reduced, and our research partners at WDFW and NOAA had suspended their research efforts. We recorded only 33 observations despite having more research nights (n=66) than in 2003–2005 (n=30) (Figure 2). No sharks were tagged; no tissue samples were collected; and none of the previously tagged sharks returned. Daily counts ranged from zero to four sixgills with no sixgills reported on 42 research nights. A Mann-Whitney test of the 2003–2005 and 2008–2015 data sets showed a significant difference (Z=2.5.8392; p-value=0.01). The sex ratio did not differ from the expected ratio of 1:1. In addition, sixgills behaved differently: they rarely fed on the bait and they didn’t stay long enough for divers to insert marker tags. No sixgills have been seen at the Seattle Aquarium since July 2015. There have, however, been sightings of sixgills in Puget Sound. Recent recreational diver sightings have come from Redondo Beach, WA (unpublished data) and Have Sound, BC (D. Gibbs, pers. comm); the IPHC caught 19 sixgills in May 2014, and the WDFW Puget Sound Ecosystem Monitoring Program caught between two and six sixgills each year in 2010, 2011, 2013 and 2015 (D. Lowery unpublished data). Thus sixgills remain in Puget Sound, just not at the abundance levels of the early 2000s, and we do not know when or if we will see similar abundance levels again.

References


Acknowledgements

This research was supported primarily by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), and Washington Department of Fish and Wildlife (WDFW). Sixgill research in Puget Sound is conducted with a permit from the National Marine Fisheries Service (NOAA). Seattle Aquarium and final return was nearly two years after our first sighting.

Seattle Aquarium

Denise Griffing, d.griffing@seattleaquarium.org
Shawn Larson, s.larson@seattleaquarium.org
Jeff Christiansen, j.christiansen@seattleaquarium.org
Joel Hollander, j.hollander@seattleaquarium.org
Tim Carpenter, t.carpenter@seattleaquarium.org

Seattle Aquarium

Denise Griffing, d.griffing@seattleaquarium.org
Shawn Larson, s.larson@seattleaquarium.org
Jeff Christiansen, j.christiansen@seattleaquarium.org
Joel Hollander, j.hollander@seattleaquarium.org
Tim Carpenter, t.carpenter@seattleaquarium.org