Dorsal Fin Edge Proportions and Their Relationship to Swimming Strategy in Sharks

Benjamin Janitz (bjanitz08@gmail.com)

Introduction to the Biology of Sharks, Skates, and Rays

Shoals Marine Laboratory

Dr. Ashley Stoehr, Ph.D. Biomedical Engineering and Technology, M.S. Biomedical Engineering and Technology, B.A. Political Science, B.S. Marine Biology

December 18, 2025

Abstract

Dorsal fins play a critical role in elasmobranch locomotion by providing stability, reducing roll, and enhancing swimming efficiency. Variation in dorsal fin geometry may therefore reflect ecological niche and swimming strategy. This study quantitatively compares dorsal fin leading-to-lagging edge ratios in three shark species with differing ecological roles: the spiny dogfish (Squalus acanthias), salmon shark (Lamna ditropis), and longfin mako (Isurus paucus). Using lateral-view photographs, dorsal fin leading and trailing edges were measured and expressed as proportional ratios to account for differences in overall body size. Results revealed substantial interspecific variation: the spiny dogfish exhibited the most significant leading-edge proportion (137.5%), the salmon shark showed an intermediate ratio (116.67%), and the longfin mako displayed a symmetrical fin geometry (100%). These differences closely correspond to each species' swimming behavior and habitat use. The elongated leading edge of the spiny dogfish enhances maneuverability at low speeds, the salmon shark's moderately extended leading edge supports high-speed pursuit and stabilization, and the longfin mako's symmetrical fin promotes efficient cruising during long-distance migration. These findings demonstrate that dorsal fin morphology is an adaptive trait shaped by hydrodynamic and ecological demands, highlighting the functional relationship between fin geometry and swimming performance in sharks.

Keywords: Dorsal fin morphology, Elasmobranch locomotion, Swimming, Hydrodynamics

Introduction

In the order Elasmobranchii, the dorsal fin, located on the dorsal side of the shark, skate, or ray, serves several purposes, such as stabilizing the organisms from rolling onto their sides and aiding in swimming in a straight-forward motion. The trailing edge of the dorsal fin may also create a low-pressure area that extends to the tail, increasing caudal fin efficiency and forward thrust while conserving energy (State of Hawaii, n.d.). A comparative assessment of dorsal fin edge proportions between species may reveal how fin geometry reflects ecological niche and swimming mode. Because elasmobranch fins function as hydrofoils that generate lift, resist roll, and reduce energetic cost, variation in the relative lengths of the leading and lagging edges should correlate with maneuverability, cruising efficiency, or burst-speed performance.

This study aims to quantify and compare the dorsal fin leading-to-lagging edge ratios in three shark species—Squalus acanthias, Isurus paucus, and Lamna ditropis—to determine whether fin shape is associated with differences in habitat, swimming behavior, and ecological specialization. And while individual dorsal fin morphology studies have been done, there are no specific published studies that directly and exclusively compare the morphology of the dorsal fins across all three species (spiny dogfish, salmon shark, and longfin mako) in a single, dedicated comparative analysis.

It is predicted that species that rely on maneuverability (e.g., spiny dogfish) will exhibit larger leading-edge proportions, species optimized for rapid acceleration and sustained speed (e.g., salmon sharks) will show moderate but streamlined edge ratios, and species that cruise efficiently over long distances (e.g., longfin mako) will display more symmetrical edge proportions that minimize drag during constant swimming.

Methods and Materials

Using the photographs of the spiny dogfish (Squalus acanthias), longfin mako shark (Isurus paucus), and the salmon shark (Lamna ditropis), the leading and lagging edges of the dorsal fins were measured in centimeters. The measurements begin at the tip of the dorsal fin and extend to the anterior point of the leading edge base, and the lagging edge is measured from the dorsal fin tip to the posterior point of the base. The leading edge is the numerator, and the lagging edge is the denominator; dividing the leading edge by the lagging edge and multiplying the quotient by 100 yields a percent length. The percent length given represents the percentage of the lagging edge that the leading edge measures. Because all dorsal fin measurements were derived from images rather than physical specimens, absolute size values cannot be compared directly between species. For this reason, fin-edge ratios were used instead of raw lengths. Only fins photographed in lateral view with minimal distortion were selected to reduce parallax error. All measurements were taken three times and averaged to minimize observer variability.

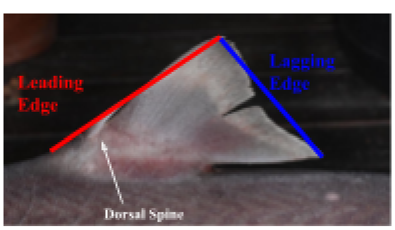
Figure 1

Common Name: Spiny Dogfish

Scientific Name: Squalus acanthias

Leading Edge Length: 5.5 units

Lagging Edge Length: 4.0 units



Shown above is the first dorsal fin along with the first dorsal spine of a spiny dogfish (Pfleger, 2018)

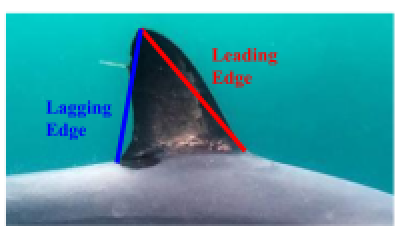
Figure 2

Common Name: Salmon Shark

Scientific Name: Lamna ditropis

Leading Edge Length: 3.5 cm

Lagging Edge Length: 3.0 cm



Shown above is the first dorsal fin of a salmon shark (Olson, 2025).

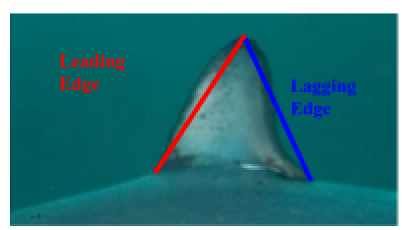
Figure 3

Common Name: Longfin Mako Shark

Scientific Name: Isurus paucus

Leading Edge Length: 4.0 cm

Lagging Edge Length: 4.0 cm



Shown above is the first dorsal fin of a longfin mako shark (Oceana, n.d.).

Results

The dorsal fin of the Spiny Dogfish appears as an obtuse triangle made up of thin cartilage; it protrudes from the dorsal side of the shark with a spine that lifts slightly from the dorsal fin but still follows the angle of the anterior edge. The fin is light brown at the base and somewhat opaque as it becomes further from its origin along the shark's back; this dorsal fin also has small lines that follow the angle of the spiny dogfish dorsal fin, seemingly with a slight corrugated texture and moderate stiffness when swimming (Maia & Wilga, 2013). The dorsal fin of the Salmon shark appears to be closer to an acute triangle and is made of thicker cartilage than the Spiny Dogfish. The Salmon Shark's dorsal seems to be a much darker brown–nearly black along the outside of the fin with a speckled gradient to a lighter brown towards the center of the fin (Abercrombie et al., 2013). The dorsal fin of the longfin mako shark resembles an equilateral triangle, with three acute angles. The coloration is a grey-teal, with a solid dark teal pigmentation along the outside of the fin, quickly grading into a light grey or blue towards the center. Similar to the dorsal fin of the salmon shark, the dorsal fin of the longfin mako shark is relatively thick and smooth (Abercrombie et al., 2013).

The dorsal fin of the Spiny Dogshark measured roughly 5.5 units at the leading edge and 4 units at the lagging edge (Refer to Figure 1), yielding a ratio of 5.5:4 and a quotient of 1.375. The quotient multiplied by 100 gives the percent length of the leading edge to the lagging edge. For the Spiny Dogfish, the leading edge is 137.5% of the lagging edge, meaning that the leading edge is 37.5% longer than the lagging edge of the dorsal fin. The leading edge of the Salmon Shark dorsal fin measured 3.5 units, with the lagging edge measuring 3.0 units (Refer to Figure

2); this gave a ratio of 3.5:3.0, or 1.11667 when the leading edge is divided by the lagging edge. The quotient is then multiplied by 100 to yield 116.67%; this percentage tells that the leading edge of the dorsal fin is 116.67% of the length of the lagging edge, meaning that the leading edge is 16.67% longer than the lagging edge. The dorsal of the Mako Shark measured 4.0 units on the leading edge and 4.0 units on the lagging edge (Refer to Figure 3); this gives a 4.0:4.0 ratio or 1.0:1.0. This equates to the length of the leading edge to be 100% of the lagging edge, meaning that the two are the same length from the points measured.

Across the three species, dorsal fin edge proportions varied considerably. The spiny dogfish possessed the most significant proportional leading edge (137.5%), followed by the salmon shark (116.67%), while the longfin mako exhibited a perfectly symmetrical fin (100%). These values indicate a progression from highly maneuverability-oriented fin geometry (dogfish), to mixed-performance geometry (salmon shark), to streamlined, cruising-adapted geometry (longfin mako).

Discussion

The spiny dogfish has two moderately sized dorsal fins, each with a sharp spine that is used for protection. The dorsal fins provide stability during moderate-speed swimming, while the spine serves as a deterrent to predators (Bester, 2025). Spiny dogfish are benthic species that inhabit deep coastal waters. The dogfish swims in slow-moving schools; not a fast swimmer, it relies on its fins for maneuverability rather than speed. The fin size helps the spiny dogfish maintain balance and control of the variable water conditions it inhabits globally. The small and flexible dorsal fin of the dogfish, with the leading edge 137.5% of the lagging edge, allows the shark to have increased maneuverability at slow speeds.

The salmon shark is found in cold, open-ocean waters and coastal waters throughout the North Pacific Ocean. It is commonly found near Japan, North Korea, and Russia, as well as along the Bering Sea (Roman, 2025). Being primarily a pelagic species, the salmon shark is usually found near the surface or at depths of around 500 ft (152 m), and has been photographed at depths of up to 837 ft (255 m) (Roman, 2025). Like the spiny dogfish, the salmon shark is a migratory species; however, its migration patterns tend to align with those of other pelagic fish it preys upon, such as Pacific salmon. The salmon shark's dorsal fin is large, upright, and pointed; this helps the shark maintain a streamlined body and swim at high speeds to catch prey. The ability to swim fast is needed because the sharks' prey, the Pacific salmon, tends to elude the shark in high-speed chases; these chases also involve rapid movement, which the dorsal fin counteracts to aid the shark's stabilization (Roman, 2025). The salmon shark's leading edge of its dorsal fin, which is 116.67% the length of its lagging edge, helps build a strong, upright fin that supports its lifestyle.

Inhabiting deep, offshore tropical and subtropical waters, the longfin mako shark tends to cruise slowly rather than at high speeds. The mako tends to have a relatively small dorsal fin, reflecting its energy-efficient movement as an open-ocean fish. The dorsal fin of the longfin mako aids more in the shark's directional control than stability. The longfin mako is considered highly migratory, but little is known about them due to their tendency to be misidentified as their cousin, the shortfin mako. Being highly migratory and an open-ocean fish, the longfin mako depends on swimming long distances and cruising; this makes the large dorsal fin, which aids white sharks and salmon sharks, redundant. The smaller fin, instead, aids in the shark's direction. Directional control is aided by the equilateral triangular shape of the makos fin, which helps regulate flow and streamline the shark for continuous swimming (Sercan et al., 2017). The longfin mako shark's dorsal fin measured 4.0 units on its leading edge and 4.0 units on its lagging edge; this makes a 4.0 to 4.0 ratio or a 1.0:1.0, meaning that the leading edge is 100% the length of the lagging edge or that they are the same length. This evenly distributed dorsal fin aids in the longfin mako shark’s constant movement through the open ocean and its long migrations. When viewed comparatively, the relationship between dorsal fin geometry and ecological strategy becomes clear. The spiny dogfish, a slower-moving benthopelagic shark, benefits from an elongated leading edge because it increases the surface area that initiates flow attachment. This enables enhanced control at low speeds and reduces the likelihood of roll when maneuvering in heterogeneous coastal environments. In contrast, the salmon shark inhabits high-energy pelagic waters and frequently lunges at salmon; the moderately extended leading edge (116.67%) provides sufficient surface area to stabilize high-speed turns while maintaining a narrow posterior edge to reduce drag. The longfin mako’s symmetrical 1:1 ratio reflects a hydrodynamic compromise optimized for steady cruising rather than burst performance. A fin with equal leading and trailing edges promotes consistent flow attachment along both surfaces, reducing induced drag during long-distance migrations. These patterns demonstrate that dorsal fin morphology among elasmobranchs is not arbitrary but closely tied to ecological niche, swimming mechanics, and energetic demands.

Conclusion

This study demonstrates a clear association between dorsal fin edge proportions and the ecological and behavioral demands of three shark species. The spiny dogfish exhibits a long leading edge suited for maneuverability and stabilization at slow speeds. The salmon shark’s moderately extended leading edge reflects its need for stability during rapid, high-energy pursuit.

The longfin mako's symmetrical fin supports efficient cruising during long migrations. These findings emphasize that dorsal fin morphology is an adaptive trait that reflects the hydrodynamic challenges posed by each species' environment. Further research with larger sample sizes and three-dimensional fin scans would improve precision and deepen understanding of fin function in elasmobranch locomotion.

Acknowledgments

I would like to thank Dr. Ashley Stoehr for her guidance and support throughout the design and execution of this study. Appreciation is extended to the Shoals Marine Laboratory for inspiring this research through their focus on aquatic ecosystems and field-based inquiry.

References

Abercrombie, D. L., Chapman, D. D., Gulak, S. J.B., & Carlson, J. K. (2013, March). *Fin Guide NOAA Tech memo_newpic_color ver 3.6.13*. NOAA. Retrieved August 7, 2025, from https://media.fisheries.noaa.gov/dam-migration/sharkfinid_guide.pdf

Bester, C. (2025, February 12). *Spiny Dogfish – Discover Fishes*. Florida Museum of Natural History. Retrieved August 8, 2025, from https://www.floridamuseum.ufl.edu/discover-fish/species-profiles/spiny-dogfish/

Maia, A., & Wilga, C. D. (2013, August 2). *Anatomy and muscle activity of the dorsal fins in bamboo sharks and spiny dogfish during turning maneuvers*. Wiley. Retrieved August 7, 2025, from https://onlinelibrary.wiley.com/doi/10.1002/jmor.20179

Oceana. (n.d.). *Longfin Mako Shark*. Oceana. Retrieved August 7, 2025, from https://oceana.org/marine-life/longfin-mako-shark/

Olson, B. (2025). *Salmon shark | Washington Department of Fish & Wildlife*. Washington Department of Fish and Wildlife. Retrieved August 7, 2025, from https://wdfw.wa.gov/species-habitats/species/lamna-ditropis

Pfleger, M. (2018, February 23). *Shark Fact Friday – A Dogfish Named Spot*. Oceana USA. Retrieved August 7, 2025, from https://usa.oceana.org/blog/shark-fact-friday-dogfish-named-spot/

Roman, B. (2025, February 5). *Salmon Shark – Discover Fishes*. Florida Museum of Natural History. Retrieved August 8, 2025, from https://www.floridamuseum.ufl.edu/discover-fish/species-profiles/salmon-shark/

Sercan, Y., Sercan, D., Hilmi, A. M., Ilker, G., & Muammer, O. (2017, June). *Comparison of flow characteristics around an equilateral triangular cylinder via PIV and Large Eddy*

Simulation methods. The SAO Astrophysics Data System. Retrieved August 8, 2025, from https://ui.adsabs.harvard.edu/abs/2017FloMI..55...23Y/abstract#:~:text=Ozgoren%2C%20Muammer-,Abstract,pattern%20were%20nearly%20the%20same.

State of Hawaii. (n.d.). *Fins & Swimming*. Hawai‘i Sharks | Fins & Swimming. Retrieved August 7, 2025, from https://dlnr.hawaii.gov/sharks/anatomy/fins-swimming/