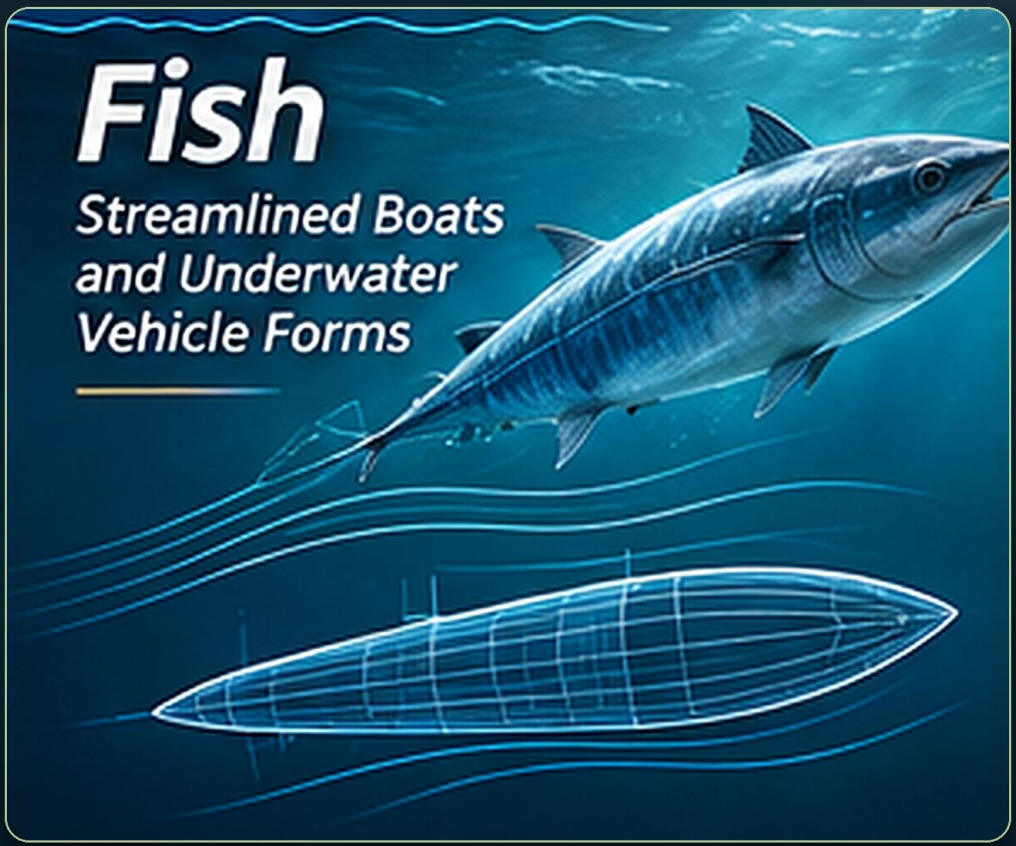
NATURE-INSPIRED INVENTIONS

WATER · VOLUME 016 / 255



From living designs to working machines

BIOMIMICRY • ENGINEERING • INNOVATION

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Fish

Streamlined Boats and Underwater Vehicle Forms

Nature-Inspired Inventions

Volume 016 of 255

WealthSphere Labs

Fish: Streamlined Boats and Underwater Vehicle Forms

Nature-Inspired Inventions, Volume 016

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About this book. This is an educational guide to biologically inspired engineering. The invention concepts in it are design ideas for study and experimentation, not tested or certified products. Worked numbers illustrate methods unless a source is named. Nothing here is engineering certification, legal advice on patents, or a substitute for qualified professional review of anything that will carry people, loads or risk.

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Introduction: Shaped by Water

Water is about 800 times denser than air and far more viscous. Anything that moves through it pays heavily for a poor shape. Over hundreds of millions of years, fish that needed speed and endurance evolved bodies that slip through water with remarkably little resistance: rounded noses, smoothly swelling bodies, tapering tails, and surfaces that keep the flow orderly.

Engineers designing submarines, autonomous underwater vehicles (AUVs), torpedoes, boats and even pipelines face the same problem. The shapes they arrive at — the teardrop submarine, the torpedo-shaped AUV, the fine-entry hull — often look strikingly fish-like. Sometimes this is direct inspiration; more often it is convergence: the same physics producing similar answers.

This volume explains how fish bodies reduce drag, the physics of resistance in water, the history of streamlined hulls and underwater vehicles, and how designers can apply fish-shape principles. It also examines a famous case where a fish-inspired design was based on a misunderstanding, as a warning about checking biology carefully.

How this book is organized

Chapters 1 and 2 cover fish body forms and surfaces. Chapter 3 explains resistance in water. Chapter 4 surveys the history of streamlined vessels and underwater vehicles. Chapters 5 to 7 cover translation, construction and operation. Chapter 8 presents ten design concepts. Chapters 9 to 13 cover testing, failure modes, approval, a workbook and a case study.

> Figures for real fish and vessels are rounded and typical. Worked numbers are illustrations unless a source is named.

Chapter 1: Fish Body Forms

Matching shape to lifestyle

Fish body shapes vary widely, and each suits a way of life:

Body form	Examples	Strength
Fusiform (spindle-shaped)	Tuna, mackerel, salmon	Sustained fast swimming, low drag
Compressed (tall, thin)	Angelfish, sunfish	Maneuvering in reefs and vegetation
Depressed (flat)	Rays, flounders	Living on the bottom
Elongated	Eels	Wriggling through gaps
Boxy or armored	Boxfish	Protection, precise maneuvering

For engineers seeking low drag at steady speed, the fusiform fish is the main model.

The fusiform body

A fusiform fish has:

- a rounded, blunt-but-smooth nose,
- a maximum thickness about a third of the way back,
- a long, gradual taper toward the tail,
- a narrow tail stalk (caudal peduncle) before the tail fin.

The ratio of length to maximum thickness — the fineness ratio — for fast fish is often around 4 to 5. This range also minimizes drag for a given volume in many engineering studies of streamlined bodies.

Swimming and shape

The shape of a fish also changes as it swims: the body bends and the tail sweeps. Fast fish such as tuna keep most of the body rigid and move mainly the tail, keeping the body's drag low. Propulsion is covered in Volume 19.

Chapter takeaways

- Body shape matches lifestyle; fusiform fish are the models for low drag.
- Fast fish have fineness ratios around 4 to 5, with maximum thickness about a third of the way back.

Chapter 2: Fish Surfaces

Scales

Many fish are covered in overlapping scales that create a smooth, flexible surface. The scales of fast swimmers are often small and tightly packed. Shark skin, covered in tooth-like denticles, is covered in Volume 17.

Mucus

Fish skin is coated in mucus, which protects against infection and abrasion. Some studies have suggested that fish mucus may reduce friction, linked to the long-chain molecules it contains. In engineering, adding tiny amounts of long-chain polymers to a turbulent water flow can greatly reduce friction drag, an effect discovered by B. A. Toms in 1948 and called the Toms effect. Whether fish benefit significantly from this in nature is still debated.

Fins and fairings

Fins that are not in use fold flat against the body or into grooves, reducing drag. Tuna can fold their dorsal and pectoral fins into slots. This is the fish equivalent of retractable landing gear.

Chapter takeaways

- Small, tight scales give a smooth surface.
- Polymer drag reduction is real in engineering; its role in fish is debated.
- Fish retract fins to cut drag.