PART II STRUCTURE AND FORM

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Form and Movement

The great ecological diversity of fishes is reflected in the astonishing variety of body shapes and means of locomotion they possess. Indeed, much can be learned about the ecology of a fish simply by examining its anatomical features or by watching it move through the water. Equally important to students of ichthyology (if not to the fish) is that these features also form the basis of most schemes of classification and identification. The purpose of this chapter, therefore, is to provide an overview of (1) external anatomy, (2) internal support systems (the skeleton and muscles), and (3) means of locomotion.

EXTERNAL ANATOMY

Although life in water puts many severe constraints on the "design" of fishes, the presence of 20,000 or so species in a wide variety of habitats means that these constraints are pushed to their limits, resulting in many very unlikely forms. What could be more unfishlike, for example, than seahorses, deepsea gulper eels (Eurypharyngidae), or lumpfishes (Cyclopteridae)? Understanding the significance of the peculiar external anatomy of such forms practically requires study on a case-by-case basis. On the other hand, species that are more recognizably fishlike (Fig. 2.1) can usually be placed in some sort of functional category through the examination of body shape, scales, fins, mouth, gill openings, sense organs, and miscellaneous structures.

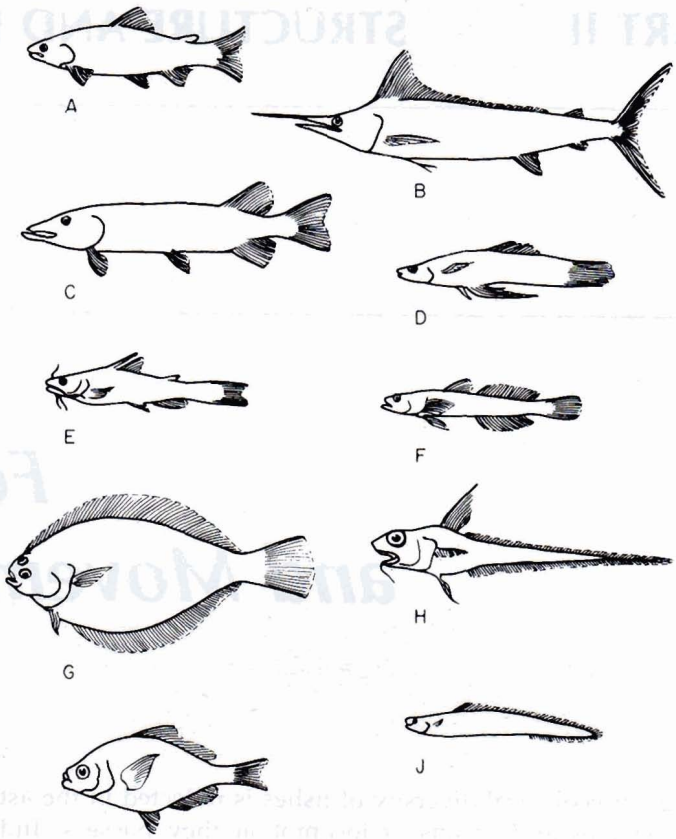

Figure 2.1 Typical fish body shapes: (A) and (B) rover-predator; (C) lie-in-wait predator; (D) surface-oriented fish; (E) bottom rover; (F) bottom clinnger; (G) flatfish; (H) rattail; (I) deep-bodied fish; (J) eel-like fish.

BODY SHAPE

Most fishes fall into one of six broad categories: rover-predator, lie-in-wait predator, surface-oriented fish, bottom fish, deep-bodied fish, and eel-like fish (Fig. 2.1).

Rover-predators have the body shape that comes to mind when most people think of fishes: streamlined (fusiform), with a pointed head ending in a terminal mouth, and a narrow caudal peduncle tipped with a forked tail. The fins are more or less evenly distributed about the body, providing stability and maneuverability. Such fishes typically are constantly on the move, searching out prey, which they capture through pursuit. Examples include many species of minnows (Cyprinidae), bass, tuna, mackerel, and swordfish. The rover-predator body shape is also characteristic of stream fishes such as trout that spend much of their time foraging in current.

Lie-in-wait predators are mainly piscivores (fish eaters) that have a mor-

phology well suited for the capture from ambush of fast-swimming prey. The body is streamlined, but it is also elongate, often torpedolike. The head is flattened and equipped with a large mouth filled with pointed teeth. In many species the mouth is largely contained in a long, pointed snout. The caudal fin tends to be large, and the dorsal and anal fins are placed far back on the body, often in line with each other. This arrangement of the fins gives the fish the large amount of thrust it needs to launch itself at high speeds at passing fish. The narrow frontal profile that these fishes present, coupled with their cryptic coloration and secretive behavior, also makes them less visible to their prey. Members of this group include the freshwater pikes (Esocidae), barracuda, gars, needlefish (Belonidae), and snook (Centropomidae).

Surface-oriented fishes are typically small in size, with an upward-pointing mouth, a dorsoventrally flattened head with large eyes, and a posteriorly placed dorsal fin. The morphology is well suited for capturing plankton and small fishes that live near the water's surface, or insects that land on the surface. In fresh or brackish water that is stagnant, these surface-oriented fishes may survive by being able to take in, through the mouth, the thin layer of oxygen-rich water that exists at the air-water interface. Most surface-oriented fish are stocky-bodied fresh or brackish water forms, such as mosquitofish (*Gambusia*), many killifish (*Fundulus*), and the four-eyed fish (*Anableps anableps*), but a number of elongate marine forms, such as the halfbeaks and flying fishes (Exocoetidae), have similar adaptations.

Bottom fishes possess a wide variety of body shapes, all of them adapted for a life in nearly continuous contact with the bottom. In most such fishes the swimbladder is reduced or absent, and most are flattened in one direction or another. Bottom fishes can be divided into five overlapping types: bottom rovers, bottom clingers, bottom hiders, flatfishes, and rattails. Bottom rovers have a rover-predator-like body, except that the head tends to be flattened, the back humped, and the pectoral fins enlarged. Examples include forms as varied as North American catfishes (Ictaluridae) with large, terminal mouths; small armored catfishes (Loricariidae) with small, subterminal mouths; and suckers (Catostomidae), sturgeons, and carp, with fleshy, protrusible lips that are used to suck plant and animal matter off the bottom. Many teleost bottom rovers have small eyes and well-developed barbels (equipped with tastebuds) around the mouth, indicating their ability to find prey at night or in murky water. Many sharks, with their subterminal mouths, flattened heads, and large pectoral fins, can also be classified as bottom rovers.

Bottom clingers are mainly small fishes with flattened heads, large pectoral fins, and structures (usually modified pelvic fins) that allow them to adhere to the bottom. Such structures are handy in swift streams or intertidal areas that have strong currents. The simplest arrangement is possessed by sculpins (Cottidae), which use their small, straight, and closely spaced pelvic fins as antiskid devices. However, other families of fishes, such as the hillstream fishes (Homalopteridae), gobies (Gobiidae), and clingfishes (Gobiesocidae), have evolved suction cups. Bottom hiders are similar in many respects to the bottom clingers, but they lack the clinging devices and tend to have more elongate

bodies and smaller heads. These forms usually live under rocks, in crevices, or lie quietly on the bottom in still water. The darters (Percidae) of North American streams are in this category, as are many blennies (Blennidae). However, the latter family contains species that range in form from "good" bottom hiders to more eel-like forms.

Flatfishes have the most extreme morphologies of bottom fishes. Flounders (Pleuronectiformes) are essentially deep-bodied fishes that live with one side on the bottom. In these fishes the eye on the downward side migrates during development to the upward side, and the mouth often assumes a peculiar twist to enable bottom feeding. In contrast, skates and rays (Batoidea) are flattened dorsoventrally and mostly move about by flapping or undulating the extremely large pectoral fins. Not only is the mouth completely ventral on these fishes, but the main water intakes for respiration (the spiracles) are located on the top of the head.

The rattail shape is another type of body shape that has independently evolved in both the Osteichthyes and Chondrichthyes. Groups such as the grenadiers (Macrouridae), brotulas (Ophidiidae), and chimaeras (Holocephali) have bodies that end in long, pointed, ratlike tails and begin with large, pointy-snouted heads and large pectoral fins. These fishes are almost all inhabitants of the deep sea, and exactly why this peculiar morphology is so popular among benthic fishes is poorly understood. The fishes live by scavenging and preying on the benthic invertebrates.

Deep-bodied fishes are laterally flattened forms, with a body depth usually at least one-third that of the standard length (distance from snout to structural base of caudal fin). The dorsal and anal fins are typically long, and the pectoral fins are located high on the body, with the pelvic fins immediately below. The mouth is usually small and protrusible, the eyes large, and the snout short. Deep-bodied fishes are well adapted for maneuvering in tight quarters, such as the catacombs of a coral reef, dense beds of aquatic plants, or tight schools of their own species. They are also well adapted for picking small invertebrates off the bottom or out of the water column. A majority of deep-bodied fishes possess stout spines in the fins, presumably because in the course of their evolution they have sacrificed speed for maneuverability and developed spines for protection from predators. Although most deep-bodied fishes are closely associated with the bottom, many open-water plankton feeders are also moderately deep bodies. This is largely the result of a sharp ventral keel, which functions to camouflage these silvery fishes by eliminating ventral shadows, thus making them less visible to predators approaching from below.

Eel-like fishes have elongate bodies, blunt or wedge-shaped heads, and tapering or rounded tails. If paired fins are present, they are small, while the dorsal and anal fins are typically quite long. Scales are small and embedded, or absent. Eel-like fishes are particularly well adapted for entering small crevices and holes in reefs and rocky areas, for making their way through beds of aquatic plants, and for burrowing into soft bottoms. Examples of this group include the many eels (Anguilliformes), loaches (Cobitidae), and gunnels (Pholididae).

It is important to recognize at this point that these categories of body shapes are general groupings. Indeed, many fishes have shapes which have