

Gobiidae — The Gobies

By Susan McDougall

These small fish make up for size by numbers, inhabiting all oceans, thriving in warm waters while ranging into the cold. Sometimes brightly colored, other times quite dull, all are short-lived. Seeking shelter near structures on the shallow ocean floor, the gobies play a surprisingly important role in the ecosystems of the vast seas.

With approximately 213 genera and 1,950 species or more, the Gobiidae family — by some called the “true gobies” — is the largest marine fish family on the planet. A member of the Gobiiformes order, which is divided into seven families, most of the goby species are small, typically measuring at 4 inches (10 cm) or less. Most common in subtropical or tropical waters, gobies are perhaps best known as inhabitants of coral reefs, where they occupy a variety of micro-habitats. For most people, gobies are most often encountered in aquariums where their variable colors and petite size add to their appeal.

The Gobiidae family includes some of the smallest vertebrates on Earth, with the tiny Midget Dwarfgoby (*Trimmatom nanus*) measuring at only .39 inches (1 cm). The largest is the appropriately named (for a Goby) “Giant Goby” (*Gobius cobitis*), a species of the eastern Atlantic which can reach a maximum size of 11 inches (27 cm).

Although most often at home in warm seas, 12 native species of this large family are present along the Pacific coast of North America, including the cool waters of the Salish Sea. Three species reside there; of these, one, the Blackeye Goby (*Rhinogobiops nicholsii*), is most common in the Strait, where it has been collected off Port Angeles and in Canadian waters as well. The Blackeye Goby is the relative giant among the three, sometimes nearly six inches in length. The other species are the Arrow Goby (*Clevelandia ios*), at 2.2 inches truly a petite fish, and the Bay Goby (*Lepidogobius lepidus*), somewhat larger at a maximum of 3.3 inches.

Most Gobiidae species are marine, but there are a few exclusively freshwater genera, particularly on oceanic islands where they are often the most abundant fishes. Other species inhabit brackish waters and streams, including several temperate water genera native to the western Pacific. The Gobiiformes order itself has been recently reorganized by researchers; most of the families include only a few species. One family, the Milyeringidae, includes six “cave fish” species, all adapted to lightless caves in warm southern waters. Eyes are useless in such a dark environment, and as energy is required to create and



Blackeye Goby (*Rhinogobiops nicholsii*)

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maintain them, cavefish gobies are sightless, their eyes having been completely lost.

By contrast, many Gobiidae species have large eyes, sometimes positioned near the top of the head, an advantageous position for a little fish that resides at the bottom of the sea. The origins of the disproportionately big eyes may derive from the tendency of some organs to retain their dimensions, being morphologically constrained, while other characteristics, such as length, decrease in response to a changing environment. This progression towards smallness will often influence other features as well.

However, it is not the eyes that comprise the most notable goby attribute, but rather the adhesive or sucking disc, a useful modification for attaching to a variable substrate, such as rocks or algae. The advantage of attachment seems apparent for a small fish whisking around from place to place. The disc is a modification of the two pelvic fins, united into one. Although not unique in the fish world, it is nevertheless a defining feature of many gobies that relates them at least in a morphological sense to other families; these include the lumpsuckers (family Cyclopteridae) and the clingfish (Gobiesocidae), both present in the Strait.

The goby family may be large, but all is not equal in the goby world, as some genera have only a few members. The Blackeye Goby genus itself consists of just this one species; the Arrow Goby and Bay Goby are also the solitary members of their respective genera. It is the coral reef gobies of the Indo-Pacific that have speciated with apparent abandon, and at least one genus consists of more than 120 species. When seeking answers as to why there are so many goby species on the planet, scientific research has focused on the tropical habitats of the southwest Pacific.

Meanwhile, at least a few gobies have made their way north, including the Blackeye Goby which could be considered a “typical” temperate water species. This goby is widely distributed, ranging from southeastern Alaska near Sitka to central Baja California. The longest of the three resident species, the Blackeye Goby is also distinguished by its large scales. The genus name, meaning “like Rhonogobius” may refer to the scales, as it is derived from the Greek “rhin,” meaning “a file” or “rasp,” perhaps from the roughened feel of the fish. “Nicholsii” honors Henry E. Nichols, a Lieutenant Commander in the American Navy who first described the Blackeye Goby on the Coast and Geodetic Survey of 1881.

The Blackeye’s mouth is moderate in size and the pelvic disc turns black in breeding males, while the dorsal fin is black at the tip as well. The body is elongate, the head bulbous, and the lips thick. Although it can mature to nearly six inches the Blackeye Goby is more typically less than 3.9 inches in length. Orange-to-yellow or tan above, with brown or greenish speckling and lighter beneath, there is often a bluish streak below the eye. This goby is most often found in muddy, silty, or gravelly bottoms, or near underwater structures, and has been recorded ranging as deep as 2,099 feet (640 m). It is confined to marine environments and is the only goby in Alaskan waters. However, it apparently does not tolerate temperatures less than 39 degrees.

This is a territorial little fish, and the males are particularly known for their aggressive behavior, sometimes defending their nests against scuba divers, a mismatch, in which large humans are treated as predators by angry gobies. Males also engage in tail beating and biting. If a female Blackeye Goby wanders by, the male responds with an elaborate courtship ritual that ends when the female enters a rough nest, often positioned beneath a rock which has been cleaned on the underside. Here the female typically lays approximately 1,700 adhesive eggs (and as many as 11,300, often in discrete batches) which are guarded by the male until hatching. Not confined to her alone, the polygynous male will seek other passing females. Territorial groups are sometimes formed by the male and associated females.

The Blackeye Goby does add one physiological wrinkle to its reproductive strategy. This is one of the hermaphroditic Gobiidae species, most often morphing from female to male although the reverse

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transformation has been observed. Presumably, this switch from one sex to the other takes place when males are in short supply or as the result of death of a dominant male.

With an average lifespan of 3 years, this little fish is quite short-lived in human terms, but in the goby world it achieves a ripe old age. A few species have life spans measured in weeks, with one living only, considered the shortest time for any vertebrate.

Feeding during the day, Blackeyes seem to find crustaceans and snails very tasty, although a variety of other invertebrates are also consumed. They sometimes feed in the water column, and often pick prey from the bottom, where they will on occasion bring in a mouthful of sand, choosing bits of food as they spit it out. In turn, they are prey for sharks, various other fish, cormorants, and marine mammals.

Two other goby species — the Arrow, and the Bay — are uncommon in the Strait, although they have been collected off the southern Vancouver Island coast. Both are found in shallow water habitats, including estuaries, tidepools, and quiet bays. Avoiding an encounter, they tend to dart into protective holes, or in the case of the tiny Arrow Goby, occasionally bury themselves in loose sand or mud. This species will also occupy invertebrate burrows and like the Blackeye Goby is a hermaphrodite. It is most easily distinguished from the Bay Goby by its large mouth and fewer dorsal fin spines. Because of their small size and timid nature, both of these gobies are difficult to observe.

Fossils and Evolutionary “Hot Spots”

Fossil otoliths (the little ear bones) of the Gobiidae have been dated to the Middle Eocene epoch, over 45 million years ago, with the modern order originating during the lower Miocene, 23-16 million years before the present. Various lineages developed over a 12-13-million-year period: such a time frame implies success in different oceanic habitats, with any setbacks perhaps obscured by the number of species present on the planet today. Ultimately, the gobies would extend their range from the Mediterranean across the Atlantic, into both hemispheres of the Pacific, where they speciated very successfully in dynamic tectonic regions (“hot spots”) — in particular, that of the Indo-Pacific. Clearly, this ancient lineage began its evolutionary path when continental size and position, and sea dynamics as well were vastly different than today.

Local extinction is evident in the fossil record, with the gobies disappearing from the Mediterranean, establishing themselves once again, invading the Pacific, possibly via the open Panama isthmus or a northern route. Most evidence for the family in the northeastern Pacific is relatively recent, with the Blackeye Goby dating to the Pliocene, between 5.3 and 3.6 million years ago, younger than the Bay Goby, which emerged about 10-20 million years ago: the Arrow Goby dates back about 6-12 million years. As scientists have delved into the past and present of the wide-ranging gobies, new species are “discovered” on an annual basis. Not all inhabit the goby-rich Indo-Pacific but instead range from places as widely distant as the Adriatic and the seas of Japan. Yet it is the southwestern Pacific, the so-called Coral Triangle region (also named the Indo-Australian Archipelago) where research has turned up dozens of new species, encompassing many fish families. However, the Gobiidae family dominates the count.

In part, this goby species-rich environment could be the result of small size and the availability of a multitude of microhabitats. Gobies in the Indo-Pacific are most commonly coral reef fish: such habitats are sufficiently diversified to enable a local evolutionary response. As an example, there are hard corals and soft corals, multi-branched and smooth corals, a mixture of hard and soft substrates at coral reef

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edges, and more. The southwest Pacific is a profoundly productive place for the Gobiidae, a family that in an evolutionary sense always seems poised for new opportunities.

The changes in local ecosystems that include the gobies and other fish families can be accelerated by tectonic forces that with time scales measured in millions of years and may seem unrelated to the dynamic living sea communities. Yet the current biodiversity of the Indo-Australian Archipelago (IAA) may be a result of high speciation rates that were a response to ancient, active “hotspots.” Three that formed over the past 50 million years have been associated with biological diversity, with one peak in the west Tethyan hotspot, followed by a later Arabian hotspot; both were the result of the collision between the Arabian and Eurasian tectonic plates. The shift to the IAA took place about 20 million years ago, as the Australian and Pacific plates began to dive below southeast Asia. Changes in plate motions have continued, making this an active region for at least 45 million years: from a human point of view volcanoes and earthquakes provide the most obvious evidence of these tectonic dynamics.

Such plate movements tend to increase shallow water habitats, at least in the earlier stages. Islands form, terranes increase, ocean circulation is modified. Each of these ongoing processes opens new habitats, promoting biodiversity. Evolution moves at a quickened pace. As the plates finally collide such opportunities decrease as mountains are built.

Ancient and adaptive families such as the Gobiidae appear poised for the opportunities provided by tectonic dynamics. Today, that fluidity is evident in the response to what appear as small differences in habitat. Some genera members are tiny; such is the case with the *Eviota* species, which number more than 100 in the IAA. Many engage in complex social behavior, including territoriality, parental nest guarding, hermaphroditism, group formation, and an obligate lifestyle with other phyla, such as shrimp. Morphological differences may be slight in closely related species, reflecting similarity coupled with slight differences in coral microhabitats. For such petite fish, the possibilities seem nearly limitless. And although genetic fluidity is not unique, goby species are the most numerous, and despite their small size play an important role in the energy exchange of the coral reef community.

Meanwhile, in the More Temperate Waters

Although the majority of the 2,000 Gobiidae species are native to tropical or subtropical saltwater habitats, many are at home in temperate seas and freshwater habitats. Most northern Pacific genera have only a few members, while others, such as those of the Pacific Northwest, count only one. These are marine species, but far to the west in Asian seas, many of the genera include members adapted to brackish and freshwater. A few are known to migrate between streams and saltwater where they spawn; these are “catadromous” fish, much less common than anadromous fish, such as salmon.

Such versatility has enabled gobies to occupy a diversity of habitats. From the Blackeye Goby, which may be pushing the limit of its adaptability in the cold waters of the northeastern Pacific, to the tiny *Trimmatom nanus*, a species at home in the shallow, warm waters of the Indo-Pacific, gobies are both numerous and widespread, sometimes showing up in places where they can disrupt existing ecosystems. At home in waters as cold as Lake Michigan, at least one member of the family, the Round Goby (*Neogobius melanostomus*) is considered a worrisome species, competing with native fish but also benefitting the freshwater community by preying on another introduced species, the Zebra Mussel.

Such adaptability, in this case the consumption of the unwanted mussel, complicates the debate over the desirability of some introduced species. And although the disruption of ecosystems by human alterations (the Round Goby was present in ship ballast in the Great Lakes as early as 1990) is a concern,

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with a genetic fluidity absent in others, Gobiidae family members may be poised to deal with unprecedented changes, sometimes contributing repairation rather than destruction.

The number of goby species increases south of the Salish Sea, along the Pacific coast, with some adapted to estuarine conditions, others to deeper waters in saltwater environments. Small size is a common feature, while senescence varies from months to just a few years, and young mature at surprisingly similar ages. Habitat in desirable crevices and burrows offers protection: such territory is vigorously defended. Hermaphroditism, most often from female to male contributed to success. In northern waters, where a few species venture, the little fish are sometimes encountered by divers, although for most people they are more likely to be seen in aquariums.

Meanwhile, far to the west, in the warm waters of the Indo-Pacific, a family closely related to the Gobiidae counts as its members the most unlikely gobies of all. These are the Mudskippers, strange fish that seem to have abandoned the idea of a protective sea altogether. With eyes on long stalks, positioned perhaps to watch for terrestrial predators unknown in the water, they venture forth, scurrying on stout pectoral fins and a rigid tail, consuming oxygen through specialized blood vessels, finding new prey. They are not our ancestors, although it would be kind of cool if they were.