Liparidae — The Snailfish

Several sisters and equally as many cousins of the "snailfish" group of fishes would make a family gathering a noisy affair, if, of course, they were in possession of voices. Only a small space in the salty waters would be required, near the bottom where little shelled creatures or some succulent worms are readily available. Room and food enough for all. Hundreds might come if the time and place were right.

But, of course, that is the problem. Not so much time as location. One sea floor is not the same as another, and, as it turns out, all those cousins who live close to the bottom do so under very different conditions. Their prey may be similar, as little invertebrates and worms are readily available and probably palatable to family members from another place. But rather it is the depth of the water column above them. Some might deal with life-threatening conditions at a communal gathering, as strangely enough, they most often live at pressures that would leave others breathless; move them upward and all manner of unpleasant things might transform a gathering into a messy affair.

Thus, it seems that for safety any social mingling would have to involve only a few. Which may be why there are so many snailfish species. Perhaps they are not able to travel freely from one depth to another, but over the eons of their existence on the planet, they have moved laterally, occupying oceans as variable as the warm Indian to the cold northern Pacific. And as for depth, these little fish range from the surface to the abyss. In terms of ecological niches the snailfish are one of the most diversified groups on Earth.

Benthic, but also ranging from the shallowest to the coldest, deepest waters, the Liparidae family, commonly known as the snailfishes, consists of approximately 29 genera and 342 species, with about 90 of them inhabiting the waters of the eastern Pacific coast. Ten species have been identified in the Strait; nine are members of the *Liparis* genus and one belongs to *Careproctus*. Of these, only a couple are considered common, while others are known from occasional collections. Named for the Strait, the scientific species name of the Slipskin Snailfish (*Liparis fucensis)* refers to "Fuca," and it is among the most frequently encountered. The Tidepool Snailfish (*Liparis florae*) is also present throughout the Salish Sea. Both snailfish species range from Alaska to California.

The common name — "snailfish" — may refer to the sluglike appearance of these adaptive fish. They tend to be smooth, covered in a mucous-like layer, sometimes with a gelatinous layer beneath the skin, an adaptation that may be an aid to buoyancy as well as serving other functions. Scaleless and elongated, with small tails, they vary in size from .39 to approximately 15.75 inches (1 – 40 cm), with at least one giant weighing in at 24 pounds, with a very long (for a snailfish) 30-inch (77 cm) body. The teeth are blunt, with three lobes of nearly equal size. The head is large, and there are two sets of nostrils; the anterior nostril is tubular and the posterior porelike. Some species have small prickles. Many have a sucking disc beneath; composed of modified pelvic fins, this organ provides a means of attachment to solid rocks and less firm algae alike. The disc is not universal, and has been lost in many species, including those that inhabit the deepest waters. However, it is present in *Liparis*, the most commonly represented genus in the Strait.

Liparis means "sleek-skinned" or "oily" and the genus numbers about 60-71 species, and is particularly well-represented in cool water regions, such as the Okhokst Sea of northern Russia. There, the *Liparis* species are estimated to comprise 22.3% of the total fish biomass. In the western Bering Sea, the percentage is even greater, estimated at over 85 percent. This is indeed a large contribution from a group of small fish.

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Snailfish are not confined to the Northern Hemisphere but range throughout the world's seas, including the Antarctic. There, they are the most species-rich fish family, with new discoveries made on a regular basis, and the region considered a center of diversity. The family is believed to have originated in the North Pacific, where today it is most represented by the *Liparis* genus, primarily a group of shallow water species. However, the family is also widely represented in deep waters of other oceans, particularly in the trenches of the southwestern Pacific. Species discovered there are considered the deepest dwelling vertebrates on the planet.

The snailfish of the deepest waters are believed to be more recently evolved, and have lost some of the adaptations of shallow species, such as the sucking disc. The *Liparis* species have the disc and are most widely represented in the North Pacific; the few Atlantic species probably evolved from those of the Pacific when the Arctic Ocean warmed.

Liparis in the Strait

Two *Liparis* species are occasionally encountered in the Strait, with a few others more infrequently observed. The Slipskin Snailfish (*Liparis fucensis*), named for "Fuca," is known to occupy depths of 13 to 1272 feet (4-388 meters), a wide depth range that hints at the adaptability of these small fish. With a range that extends from the Aleutian Islands in Alaska to central California, this snailfish most often inhabits shallow waters, although the adults tend to forage deeper than the juveniles. Slipskins are colored gray to grayish pink, with long dorsal fins that lack spines. The skin is loose and slimy, the head is small, the tail well-developed, the pectoral fins large, and the eyes are high on the head. Like other *Liparis* species, this species lacks scales. Only 7 inches (17.8 cm) in length, Slipskin Snailfish spawn from January to September. The female lays her eggs in nests, often depositing them within empty mussel shells. Males have been observed to guard the nests which may hold more than 2,500 eggs.

Tidepool Snailfish (*Liparis florae*)

Also collected in the Strait, the Tidepool Snailfish (*Liparis florae*) is similar in size to the Slipskin; this snailfish ranges from Kodiak Island in Alaska to southern California. "Florae" honors Flora Hartley Green, a pioneer zoologist at Stanford University. Tidepool Snailfish are also a shallow water species, living amongst rocks, or sometimes hidden in eelgrass and algae to depths of 50 feet (15 meters). Similar to other *Liparis* species, the Tidepool Snailfish attaches itself to the substrate with an adhesive disc. The dorsal fin is deeply notched, giving the appearance of being twice divided. The skin is loose and slimy, the body yellowish to reddish-brown in color. Maturing at only 1 inch (3 cm) and reaching a maximum length of only 7.2 inches (18.3 cm). these tiny fish eat small crustaceans and other invertebrates.

Another common snailfish in the Salish Sea and known from at least one collection in the Strait, the Showy Snailfish (*Liparis pulchellus*) also ranges from the Bering Sea to Monterey Bay and is tolerant of estuarine conditions. A bit larger than the Slipskin and Tidepool snailfish, the Showy is up to 10 inches

(25.4 cm) in length. This species also ranges from shallow waters to depths of 600 feet (183 m). Bluish to pinkish in color with grayish streaks, the Showy Snailfish species matures at 3-4 inches, and as with other family members is quite cosmopolitan in its tastes, with a palate that includes worms and fishes. Chinook salmon apparently find them tasty.

At least six other snailfish species have been recorded in the Strait, but all are considered rare. Two of these are relative giants, with the Lobefin Snailfish (*L. greeni*) reportedly reaching more than a foot in length at its maximum, and the Marbled Snailfish (*Liparis dennyi*), sometimes achieving a similar size. This group also includes a tiny snailfish; at less than three inches the Ringtail Snailfish (*L. rutteri*) is amongst the smallest of its genus.

Surface to Trench: the Depth Range of the Liparidae

In the Strait of Juan de Fuca, an encounter with a snailfish is most likely to take place in shallow waters; here the fish might be seen attached with their ventral disc to eelgrass or rocks. Not particularly inviting to the recreational or commercial angler, they are more of a curiosity, occasionally seen by divers, but for the most part of passing interest. Yet here is a family with members that range from the surface to more than 26,450 feet (8,000 m), occurring in seven of the world's deepest trenches. They are also present in all oceans, most typically in cool waters, including the icy cold of the Antarctic. These little flabby fish are ubiquitous, if less noticed.

With a depth range greater than any other fish family, the Liparidae are indeed unique. They are the most common group inhabiting the "hadal" zone (in reference to "Hades," the Greek god of the underworld) which, defined as a depth range from 20,000 to 36,000 feet below sea level (6,000 to 11,000 meters), is confined to the deepest ocean trenches. Located in the southwestern Pacific, approximately 225 miles from Guam and named for an island arc, the Mariana Trench is the deepest trench on the planet, with a maximum depth of over 36,000 feet (10,972 m) near its southern end. It is in this long trench that a snailfish — named *Pseudoliparis swirei* — was filmed and captured by researchers at a depth greater than 26,000 feet (7,925 m). Adding new snailfish species to the family is not particularly unusual; finding one at such depths was record-setting.

There are some unique physical features of this deep-sea snailfish. Diverging from surface dwelling snailfish approximately 20 million years ago, *Pseudoliparis swirei* is considered taxonomically closest to Tanaka's Snailfish (*L. tanakae*), a shallow water snailfish. *Pseudoliparis swirei* sports a nonpigmented transparent skin. Through the filmy whiteness of this covering, the muscles and internal organs can be seen. The stomach and liver are enlarged, as are the eggs. The skeleton is incompletely ossified, and the skull not completely closed. The fish lack photoreceptors, making them essentially blind, although some may retain light-sensing ability. Examination of the stomach has revealed that their most frequent prey item was a crustacean*, Hirondellea gigas*, another trench dweller that deals with similar challenges to survival in the deepest waters on Earth.

Other snailfish also dwell in trench habitats, with at least one, the so-called "Ethereal Snailfish," seen at a depth of 26,831 feet (8,178 m), surpassing previous vertebrate records; however, this fish has never been collected and thus has not been assigned a scientific name. The Ethereal Snailfish is also native to the Mariana Trench. Interestingly, the larvae of some of these deep sea snailfish inhabit relatively shallow waters.

At one time considered lifeless, since the 1950s the deep sea has slowly begun sharing its living secrets. Most residents in this extreme environment are invertebrates, but fish are also present, following available food sources downward, but taking a long time to do so. Perhaps something unique in the snailfish genome contributed to the slow descent, a flexibility that enabled physiological and chemical changes not possible for other families. Few have made the journey, as the challenges are many, and researchers are only beginning to understand the evolutionary modifications revealed by these unique creatures.

Pressure that approaches nearly a thousand atmospheres in the deepest trench would seem to preclude any vertebrate from making the transition; death would be instantaneous in such bone-crushing habitat. Why go there? One reason, as always, is food, and as it turns out, trenches can be surprisingly resource rich, with debris filtering down from the waters above and little invertebrates busily going about their own lives. The slope is greater there than in more shallow waters, and the environment dynamic, with occasional disruptive slides, creating both danger and opportunity. Fish may have shorter lives in the deep, but the resource reward and the sheer size of the environment perhaps implies a certain inevitability to their presence. This was a big place, ready for occupation, one that offered a very specific niche for a flexible predator.

And although not apparent to land-dwelling creatures who observe the ocean's surface only, deep waters are the norm. Fifty percent of the Earth's surface is represented by ocean waters deeper than 9,843 feet (3,000 m). Dry land is the exception.

Making the Dive

The slow move was not without change, and much effort in recent years has been devoted to trying to understand those adaptations that make life in the depths possible. The fish that looks as much like a slug as a more conventional fish, has become a subject of scientific scrutiny. Models are built, skeletons photographed, fish collected, all important to trying to understand what has enabled snailfish to thrive in an unending darkness but an inviting one. For here the prey may be plentiful and predators rare.

It was expected that loss of features rather than acquisition would characterize species such as *Pseudoliparis swirei* and others. At the very least, bone density should be reduced, a change that would promote buoyancy. This implies as well that structures, such as the skull or the jaws, or even the eyes, which are of little use in perpetual darkness, would undergo a reduction in form and function. Questions such as the openness of the skull of deep-sea fish and its possible benefits in withstanding pressure would be asked. Would cartilage replace bone, and most importantly, what genetic changes would be necessary to survival? What about metabolic rate? Would it be less than surface dwelling snailfish?

A gelatinous layer present in many snailfish, including those of deep waters, may also promote buoyancy, and certainly a feeding style that consists of sucking food in rather than chasing it down is an advantage where eyes are useless. At the same time, a structure such as a disc seems less useful and only adds weight. Protein evolution may have sped up, while metabolic rates slowed down. Changes were necessary and inevitable, but as with so many factors in the biological world, the answers to how they come about is more complicated. It is not a linear world.

For example, studies of the advantages of gelatinous tissue reveal that while it is an aid to buoyancy, the reasons for its commonality, particularly in the snailfish, is more complex. Robotic snailfish models reveal that gelatin promotes a more streamlined shape, while at the same time requiring less energy than muscle to maintain. Drag is reduced, and body size increased at low cost. In the hadal environment, small changes can make a big difference in performance. Not a feature of the Liparidae family alone, gelatinous tissues are present in at least 200 species of fish, representing thirteen families. Many species actually float in seawater, while at the deepest regime fish may be negatively buoyant, slowly sinking, yet aided by their cost-effective soft tissues.

Other studies show that while bone density does decrease with depth, it is not a simple progression. And while snailfish have at least two options for reducing weight, including reducing bone size and losing skeletal pieces, such as the suction disk, other ecological factors are involved. Thus, it is not just a matter of going deep, but rather where that occurs, the temperature of the water, the geophysical dynamics, and a multitude of other elements of the species' environment.

With the greatest depth range of any fish family, even the snailfish have limits. Researchers have learned that a chemical, trimethylamine oxide (TMAO), a compound that counteracts pressure, may become so concentrated with depth that the fish cannot compensate for the difference in chemical composition of their body and seawater. Instead of water flowing out of the gills, and salts in, the process would be reversed. Whether physiological changes could take place rapidly enough is the question.

Thus, a fish that appears simple in form and lacks many of the features of more conventional species, displays a surprising fluidity. Snailfish are small but common. Separating from its nearest relative 10 million years before the Mariana Trench formed, the deep dwelling *Pseudoliparis swirei* evolved from a surface dweller to a denizen of the deep, following prey downslope to depths that nearly mirror the great Himalayan mountains above. Only a few others have made this sort of transition, most of them close relatives.

Ask a human to visualize and describe a fish, and it is most likely that picture will be of a robust salmon or perhaps a fearsome shark. However, if fish could talk they would reveal a different perspective beneath the boundary between water and air. This is a world of one-sided fish, confined to existence on the sandy bottom; of long skinny fish clinging to strands of plants with relatives above; and of fish with spines and bumps and modified fins that clamp onto rocks. Schools of "regular" fish may pass by, but in the briny deep, from the surface to thousands of feet below, form enables function, as fish reveal at least in part the reasons for their long tenure on the planet.

Their sojourn has not been confined to the depths nor the shallowest waters, but like plants on a mountainside, the snailfish have occupied the horizontal habitats from the coldest waters to the inviting temperate seas, with their unusual form and adaptability taking advantage of all the ocean has to offer. There they are both limited and opportunistic, and as with other sea creatures, subjected to many changes beyond their control.

At more than five miles beneath the surface of the sea, the blind snailfish may exhibit less flexibility than its cousins above; here it is as confined to its habitat as humans are to theirs. Strangely, it cannot survive in the world of diminished pressure, having evolved in harmony with a slow sinkage to the lowest elevations on the planet. And for these out-of-sight creatures there is a crucial dependence on what filters down from the surface. The quantity and composition of the descending nutrients are affected by anthropogenic activities. Global warming affects oxygen levels; less oxygen is dissolved in warm water than cold. Deep sea habitats might be considered insulated from what transpires above, but they are as sensitive, if not more susceptible to alterations as their shallow water kin.