Plainfin Midshipman (Porichthys notatus)

The sound of lapping waves, the scent of the sea, the last pinkish rays of the setting sun, the fatigue of a long work week fading from memory as the anticipation of a relaxing two days on the water begins. Life in a floating home, protected against the vagaries of nature by a stout concrete foundation, close to a great city — it is the best of all worlds. Settling down with a good book, the Sausalito resident drifts off to a dreamless sleep.

The sound began suddenly, reverberating from below, or was it above? Like a low flying airplane, except that it did not recede as it should when the plane passed by. Was this a dream? Why didn't it end, either in sweating terror or a gentle return to a peaceful slumber? Rather it continued, neither increasing in volume nor fading away. Sleepless now, the clock barely past ten, she got up and walked to the deck. The intensity was less here. Perhaps sleep would return if she nestled down on a lounging chair, wrapped in a warm blanket.

Although no airplane lights brightened the sky, the pulsing sound was repeated the following evening, this time for more than an hour, rather than minutes, and in the morning the neighbors gathered, discussing theories. Was the Navy conducting some secret test? Could it be a generator, installed in a new building across the bay?

The days shortened, and the strange noise ceased. All was as quiet as a human community could be, and for a time, the incident was forgotten. Yet three years later the droning returned, more intense this time, and the sleepless residents engaged in discussions once again. Confident in their protection against the sea by the sturdy construction, it did not occur to them that a biological element might be responsible.

Enter an aquarium employee, and the mystery of the strange pulse was solved. Summertime, when romance above the waters was apparently felt below the sea's surface as well. Hidden from view, a wide-mouthed, flat-headed male "toadfish" was also in a courting mood. In anticipation of fatherhood, he had built a nest, and now, wishing to attract a mate in the watery depths, had begun his persistent and hopefully irresistible hum. Named the Plainfin Midshipman by humans who saw a likeness between luminescent spots, also part of his courtship, and a seaman's shiny coat buttons, the little fish was engaged in an ancient courtship ritual. Eagerly, he sought more than a single mate, and so when laying was complete, the song began once again.

The story of the fish and the perplexed people attracted media attention, and within a short time the idea of a festival celebrating the humming fish was born. Named the Humming Toadfish Festival, complete with a Grand Marshall, a parade, booths, marching kazoo band (supposedly to imitate the Plainfin's song), food, beer, and strange, "fishy" costumes, this was a fun time above the waters. Below, the demands of courtship continued.

Perhaps the toadfish beneath resented the attention; all they were doing was answering nature's oldest call. In any case, the fishy community declined, the humming ceased, and with their departure, the human festival also ended, its organizers and participants now sleeping soundly once again.

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Common names often invoke images of appearance, some of them quite lovely, as with "Rosylips Sculpin," or descriptions of lifestyle, such as "Northern Clingfish." The designation given to the Plain Midshipman family — toadfish — hints at appearance and more, for these are fish that are seasonally vocal, emitting gruntlike sounds that reverberate in their ocean home.

The family name, Batrachoididae, also refers to the strange toadfish face — *batrakhos* is Greek for "frog." It is the only family in the Batrachoidiformes order, but with 21 genera and 83 species, it is a group of respectable size. Represented in nearly all of the world's oceans, although absent from the coldest waters, these are primarily marine fish, although there are freshwater species in South America. Most toadfish are small bottom fishes, occurring in deep to shallow waters and sometimes in brackish environments.

Porichthys notatus, the Plainfin Midshipman, ranges from southern British Columbia to Puget Sound and from Humboldt Bay in northern California to southern Baja California. It is apparently absent south of Puget Sound to Cape Vizcaino in northern California, an odd gap in distribution. The genus name, *Porichthys*, means "pore" and "fish," and *notatus* is Latin for "spotted." The "pore" designation refers to the small photophores, numbering 700 or so in the Plainfin Midshipman, which line the sides, belly, and form a "V" on the throat. These little dots luminesce, at least in the southern and coastal fish.

There are 18 species in the *Porichthys* genus, eight of them native to the eastern Pacific. The only New World fish with photophores, these are bottom dwelling fish, often of sandy habitats, where they are known to dig in, revealing only their large mouth and bulging eyes above the substrate. The Plainfin Midshipman inhabits the intertidal zone but also resides as deep as 1256 feet (383 m), although most live above 820 feet (250 m).

With a maximum length of 16 inches (40 cm) and a weight of 1.7 pounds, the Plainfin Midshipman more typically is about 6.3 in (16 cm), with the so-called "male guarders" larger than females and the "Sneaker Males" only about 4.75 inches (12 cm.) They lack scales, have large heads, sharp teeth, and a spine on each gill cover. Colored brownish to olive and sometimes exhibiting an iridescent sheen, the Plainfin Midshipman can live to an old age of 7 years, but more typically only five. They eat a variety of crustaceans and small fishes as well, and are in turn prey for birds and mammals, fish and squid, and terrestrial animals such as mink. Although small, they were a food resource for Indigenous peoples.

The photophores may be a distinctive feature, and especially important during the breeding season, but interestingly, they are not functional in all populations. The Puget Sound Plainfin Midshipman apparently does not luminesce, the reason not being hesitancy but rather chemistry. Activation of the photophores requires luciferin, a compound present in plankton such as the Sea-firefly

(*Vargula hildendorfi*), a species that is bioluminescent. This little ostracod is absent from the Sound, and without it in the diet, the Plainfin Midshipman does not glow.

The photophores are important to nesting male Midshipmans, but they may also be employed to confuse predators. Matching the light from the sparkling waters above, the little fish might confuse larger animals below, their bright spots providing an effective camouflage.

Male Plainfin Midshipman produce their unique humming sound with vibrations of specialized muscles attached to their swim bladder. Other grunting sounds are also emitted by the male, sometimes as a sequence or "train," and both sexes can emit single "growls." However, only the males "hum," with the performance lasting seconds to hours and taking place at night. This fish symphony begins during breeding season when the males also busy themselves with nest building, undertaking this activity following an inshore migration, with nests constructed on substrates that are soft but located close to harder surfaces. Completing the excavation, the male seeks to attract one or more females by beginning his watery song. When a female investigates, the male pauses his hum, sometimes for several hours as she adheres her eggs around the nest. He fertilizes the eggs, and when she is finally done, chases her from the nest. Then the male takes on parental duties, fanning, brushing, and guarding the eggs. Once again, he begins to hum, with the hope of attracting another female. The male may get hungry during the guarding duties which can last for many days, and he is known to snack on the tempting clutch. And it is a busy and exhausting time, for it would seem that Midshipman reproduction is more complicated than a mating of two. Not only does the humming male guard the eggs but also must contend with a so-called "Type II" male hanging around (he is the type "I.") Lacking the ability to hum, this smaller male waits nearby, sneaking into the nest when opportunity allows. Known as "sexual parasites" these males are much less numerous but apparently successful in fertilizing eggs laid by females attracted by the hum of the larger males.

As many as 2,000 eggs may be present in the nest, and the incubation is long, as much as 45 days. After the young hatch they attach to rocks where they stay for weeks, finally departing to shallow waters. Older fish move to deeper habitats where they feed in the water column.

Plainfin Midshipman hums and human voices

Perhaps it was inevitable that the Plainfin male's hum would attract the attention of scientists. Delving into the biology of the Plainfin vocal communication was much easier with a fish than many other species, including humans. One of the original goals was, and continues to be, a possible connection between mammalian speech and fish calls. This is not an especially far-fetched idea. After all, at some ancient level all animal life (and plants, too) are related. The question is, can a direct relationship be elucidated. Will a fish reveal to humans a commonality between their simple hums and the complex sometimes nearly overwhelming tendency of humans to express themselves.

Even for the simple language of a Plainfin, scientists did not assume a simple answer to the sound-producing mechanism. It was known that the swimbladder, activated by muscles, was the source of the humming. However, ultimately the "command" to make a sound, whatever its motivation — in this case a hormonally-driven call — resides in the brain. And the similarity of the Midshipman brain and that of humans has for some years suggested to researchers the possibility of commonality in the complicated pathway between a "command" for sound and its ultimate utterance.

The ears play a vital role in sound production, for without them, there is little reason for this complex mechanism to evolve. And ears do more than just perceive a sound; they must distinguish

between one's own sound production and that of the surrounding environment. The fish inner ear resembles that of humans, except that fish lack the cochlea, a coiled organ unique to mammals. Commonalities with other vertebrates are present as well; in particular the ability to produce acoustic signals on a millisecond time scale, shared by birds and mammals alike, suggest the possibility of "convergent" evolution. This embodies the idea that different lineages develop similar solutions to environmental challenges and opportunities.

By contrast, selection for a specific response, such as creation of sound, can reflect a shared, often ancient lineage. Thus, it is possible that the last common ancestor of mammals and fish evolved to produce sound with a similar mechanism, and the activation and firing of specific neurons for this form of communication is known to originate in the hindbrain, a "corridor" that connects the back of the brain with the spinal cord, present in both fishes and tetrapods, including ourselves. Here a Central Pattern Generator ("CPG") can produce sound on a millisecond timescale. It is both complicated and the subject of ongoing research, but it is known that the hindbrain is very ancient; research suggests it evolved as much as 575 million years ago, a time when animal bilateral symmetry also developed.

Why such an old part of the brain would be a common site of sound production for animals as apparently diverse in form and habitat as fish, birds, and mammals, is not clear, but it does imply possibilities of communication dating back to a time prior to the appearance of fish. It would seem likely that the Plainfin Midshipman is a recent player on this stage of sound and motion as well.

What it does mean for application to human afflictions is possibly far-reaching. As an example, the loss of speech due to stroke might be more fully understood with fish sound production research. At the very least studies of Plainfin vocalization provide insight into the function of the brain, with all its complexities, an understanding that may contribute to treating human brain disfunction.

Another area of research involves the Plainfin swimbladder, which is activated by high frequency muscular vibrations in the production of sound. Understanding such unique muscle capability may have applications to human muscular diseases. Answers to such connections between fish and human speech and movement will undoubtedly occupy researchers for many years to come. Hopefully, understanding will help both humans while making a strong case for a complexity of fish physiology and communication, perhaps little appreciated prior to the entry of the Plainfin Midshipman into the laboratory.

Scientific articles concerning Plainfin Midshipman are numerous, with new results reported in the literature on a regular basis. Laboratories are dedicated to this little fish, sometimes referred to as "ugly," but in the end as intriguing as any species of the watery world. The little Plainfin even has its own website. Perhaps it is time to create a festival dedicated to Porichthys notatus*, once again. If we are lucky, the busy male, preparing his nest and settling in, may create his home close enough to share his hopeful hum.*