Eelpouts — Zoarcidae

By Susan McDougall

The first rivulets of water inched over the brown land, creating narrow channels that barely impeded the terrestrial inhabitants. In the sea, movement through the new pathways was tentative at first, then accelerated as time passed. This was no temporary tidal flow; an immense new continent was breaking free and, as it moved inexorably southward, the opening would widen and deepen, eventually enabling the waters of the cold ocean to flow in a great current around the departing land. As it moved the nascent continent would undergo a transformation from earthy colors to white, altered by the cold, circulating sea and its eventual resting place at the bottom of the planet. Air-breathing animals would arrive, their lives dependent on the cold waters at the continent's edge. And in the icy sea, the change in the animal communities would be profound. No human being would witness it, for when the parting commenced piece by piece over 30 million years ago, Homo sapiens *did not exist.*

The final breakup of the great Gondwanan supercontinent, culminating in the creation of Antarctica, brought about the formation of a unique ocean current, a cold, deep flow that would in time impact all the oceans of the Earth. Within this great circulating body of water, resident fish moved into new territories, unique enough to enforce blind change in response to a mix of challenges and opportunities. They were not isolated, as developing connections and influences on the planet's waters invoked changes to fish form and habitat. There an unknown ancestor would divide into two lineages of fish that over eons would inhabit the coldest waters at both northern and southern oceanic extremes. One of these two, the Notothenioidei, would stay "home" in the southern oceans, where in time they would dominate the fish population of this new Antarctic Circumpolar Current. The other, the Zoarcioidei, would wander north and west, adapting and eventually radiating into hundreds of species. As the northern oceans modified in response to the southern changes, the fish would explore and adapt to new habitats, eventually reaching waters that defined the continental boundaries of more eastern lands.

These pioneers that in time would occupy both the Northern and Southern Hemispheres were members of the Zoarcidae, a family that appeared rather late in the adaptive story of its parent group. Evolving approximately 10 million years ago, and concentrated in the northwestern Pacific, today the Zoarcidae includes at least 46 genera with 240 species, and undoubtedly more, as discoveries and identification are ongoing. Called the "eelpouts," they are bottom-dwelling fish, sometimes present at great depth. Most diversified in the Northern Hemisphere, at least 24 eelpout species are endemic to the icy waters of the Antarctic. Also present in the tropics, eelpouts occupy the cooler, deeper waters in these warmer regions. Many species are rare, or at least not commonly reported, and although most live in benthic habitats, often on continental shelves, eelpouts are observed in shallow waters as well.

Of the many Zoarcidae genera, two — *Lycodapus* and *Lycodes* — are represented in the Strait of Juan de Fuca. The Blackbelly Eelpout (*Lycodes pacificus*) is the most common eelpout throughout the Salish Sea, although in the Strait it is primarily restricted to the eastern waters, such as Discovery Bay. The Smallhead Eelpout (*Lycodapus parviceps*) is uncommon but has been recorded at a few locations, and the Wattled Eelpout (*Lycodes palearis*) has also been collected in scientific surveys.

"Lyco" is from the Greek "lycos" for wolf, and "oides" for similar; "pous" means "feet." With at least 147 members, *Lycodes* is the most species-rich genus of the Zoarcidae. The family is present in the Pacific and Atlantic, with an apparent center of divergence in the northwest Pacific. All species are

marine. The largest is the Ocean Pout (*Zoarces americanus*), an Atlantic resident, measuring up to 3.61 feet (1.1 m). And as will be explained in detail below, these three species and many of their relatives have "anti-freeze" in their blood, an adaptation to cold northern waters.

As the common name implies, Zoarcidae fish are eel-like in appearance, with long slender, somewhat compressed bodies, and dorsal and anal fins continuous with the caudal fin. Pelvic fins are typically reduced, while pectoral fins can be large. Lateral lines are single or double, and sometimes incomplete. These fish do not have a swim bladder. Color, particularly for the benthic species, tends to be muted, varying from greenish to brown. Eelpouts have small, rounded scales, ovoid heads, and large eyes. Most lay eggs, with internal fertilization a possibility in some, but at least two genera give birth to live young. Egg production tends to be small, and development may take months, with the young fully formed when born. A few members of the family occur in very deep waters, the "abyssal" depths, defined as those from 4,000 to 6,000 meters, and at least one has been located in the "hadal" zone, at more than 20,290 feet (6160 m) in the Marianna Trench. As ocean bottom species, with a tendency to slip through collecting nets eelpouts can be difficult to observe, and their spawning habits are poorly known.

The eelpout suborder, the Zoarcoidei, includes four other families present in the Strait in numbers sufficient to be recorded or collected. Like the eelpouts, these relatives are elongated fish, many of them found in shallow waters, such as the wary Graveldiver (*Scytalina cerdale*), and the gunnels (family Pholidae). The oldest family is the Bathymasteridae, the ronquils; this small family has only seven species and was the first to split away from its ancestral lineage, as much as 18 million years ago. The most recently evolved is the Zoarcidae.

A Unique Antifreeze

Blood proteins that protect against freezing are present in both Antarctic and Arctic fish species. Fish body fluids can freeze at -.7 to -.9 °C (approximately 30° F) while polar oceans may register temperatures more than a degree lower. Thus, protection against freezing is vital for fish that live in the cold sea. With their distribution in both northern and southern cold seas, the suborder Zoarcoidei have evolved a unique antifreeze, known as a type III AFP; this chemical has been isolated from at least one member, the Ocean Pout (*Zoarces americanus*). The *Lycodes* genus, present in the Strait, includes at least one species, the Arctic Eelpout (*Lycodes polaris*), also known to have this antifreeze protein in its blood, and family members in the Antarctic carry the unique chemical as well.

The presence of antifreeze in both the northern and southern Zoarcidaes is problematic for researchers, as the question arises as to continuity between the species. Since the eelpouts moved southward, eventually reaching Antarctic waters, it is conjectured that they would have to pass through warm waters, where it seems likely the antifreeze protection would be "lost." Yet it is present in Antarctic eelpouts. Thus, it seems possible that such a transit would have taken place in deep, cool waters, genetically preserving that ability to withstand the cold. Such a migratory cold route would have depended on the topology of the ocean bottom.

By what route this movement took place, and what changes it brought about is a subject of research, but what is known is that Antarctic eelpouts do possess this same chemical protection against freezing that their close northern relatives do.

Fossils and Movements

The fossil record of eelpouts is sparse, although the otoliths (ear bones) of one member of the family found in southern California are dated to 3.2 to 1.9 million years ago. These small bones are of the Blackbelly Eelpout, the same species present today in the Strait. Zoarcidae fossils unearthed in late Pleistocene deposits in Canada include *Lycodes* species and the extant Wrymouth (*Cryptacanthodes maculatus*), a large, shallow water fish native to the northwestern Atlantic: wrymouths are also present in the northern Pacific.

Other suborder Zoarcoidei families are also rare as fossils, although researchers have found enough evidence to place the origins of the Zoarcoide in the Eocene, as much as 57 million years ago. It is posited that at this time the eelpouts split from the Notothenioidei, the Atlantic "cods" or icefishes. Both groups were adapted to cold waters. In time, some eelpouts would reinvade the southern waters; in particular, the Zoarcidae family is represented in the Southern Hemisphere and is the only eelpout family present there. Eelpout progenitors radiated throughout the Northern Hemisphere, while the icefish dominated south of the equator. This "split" occurred prior to the end of the Eocene, about 35 million years ago, when the separation of Antarctica was complete. Today, it is the Notothenioidei that dominate the fish population of the Antarctic Ocean. Unlike the Zoarcoidei which moved north, evolving into several families and many genera and species, and subsequently reinvading the southern waters, the related Notothenioidei remained south of the equator, with occasional "strays" to the Northern Hemisphere.

Genetic analysis of 61 species of eelpouts, and examination of fossils has revealed more information about the evolutionary timeline of the Zoarcoidei suborder. From these studies divergence times of the several families from a member of the Notothenioidei, has been calculated. As an example, the diversification of the Stichaeidae (pricklebacks) approximately 11 million years ago marks the beginning of the radiation of the eelpouts. Most species and genera present today separated around 3.2 million years later; the Zoarcidae genus *Lycodes* is one of the youngest.

Eelpout speciation is considered most likely to have transpired in the northwest Pacific, specifically near the Sea of Japan, and the western Bering Sea as well. The Zoarcidae family is represented by at least 125 species in this region. From this evolutionary center, the eelpouts have radiated south and east, eventually establishing populations in the Antarctic and the Atlantic oceans.

The Atlantic eelpout "invasion" may have occurred either across the northern seas, or possibly the Isthmus of Panama. Submerged prior to about 16 million years ago, and shallow by 7 million years ago, transgression across the emerging isthmus would have been difficult for deepwater fish, such as eelpouts, although it is conjectured that at least one Zoarcoidei family, the Cryptacanthodidae (wrymouths), originated via this route.

However, the most likely route for eelpout incursion into the Atlantic occurred when the Bering Strait opened approximately 5.7 Ma, connecting the polar and eastern seas. Several genera speciated in the Atlantic prior to subsequent closure of the sea, isolating the new species — however, a few of these eastern genera are also present in the Pacific. Perhaps this is the result of a more recent incursion. And at least one Atlantic species, *Lycodes terranovae* crosses the equator, ranging from the northwest Atlantic to southwest Africa.

Eelpouts of the Strait

The Blackbelly Eelpout is a medium sized fish that reaches a maximum length of 18 inches (46 cm) and ranges from the Aleutian Islands, across the Gulf of Alaska, and south to northern Baja California. It lives in shallow waters to depths of 3,399 feet (1,036 m) and is most common on muddy bottoms where it is sometimes observed wound into a tight coil. Elongated, with body-length dorsal and anal fins, and small pelvic fins, named for their blackish belly the Blackberry Eelpout is marked with a dark spot in front of the dorsal fin. The head is rounded with a short snout and large eyes. The males have a larger mouth than the females.

Blackbelly Eelpout (*Lycodes pacificus*)

With a life span of 5 years or more, males grow more rapidly than females, and sometimes mature at six inches and 2 years, although most are older. Females can also mature at a small size. Oviparous, the females produce as many as 50 eggs but often less. Although little is known about their spawning behavior, Blackbellies have been observed to spawn from autumn to winter. The large egg size implies a significant maternal investment, and it is known that the larval stage is almost absent. Burrowing seems likely and it is possible that some parental care is involved. It is most likely that as with other family members, Blackbellies lay their eggs in benthic habitat. However, studying such a deepwater species is always difficult, and even trawl surveys are limited in scope.

The Blackbelly Eelpout is known to move to shallow waters at night where they feed on worms, crustaceans, bivalves, and brittle stars; in turn they are eaten by larger fish and sea mammals. Edible but not considered particularly tasty, they are sometimes used as bait for rockfish, greenlings, and cod.

In the eastern Strait, trawling surveys have collected Blackbelly Eelpout, particularly in Discovery Bay. Placed in the “other fish” category by the Washington Department of Fish and Wildlife, in 2005 surveys estimated a population of 22.8 million; this eelpout had nearly doubled in abundance in a short span of three years. Uncommon in the western Strait, Blackbellies are quite abundant in Hood Canal and the waters of Whidbey Island and are present throughout Puget Sound.

With a potential size of 24 inches (62 cm), and a weight of 1.1 pounds, the large Wattled Eelpout ranges from eastern Kamchatka, across the Pacific to the Gulf of Alaska and south to Oregon. In the Strait they have been caught in trawl surveys. This eelpout occurs in waters as shallow as 82 feet (25 m), but also inhabits deeper zones, to 3,035 feet (925 meters). Found in muddy bottom habitats, they eat clams, crustaceans, as well as brittle stars and fish. Arrowtooth flounder, halibut, and cod are known to

prey on them. The Wattled Eelpout dorsal, caudal, and anal fins are almost continuous. The fins and the body are reddish-brown, with white bands on young fish. A blackish blotch on the dorsal fin fades with age. This fish has dense scales on the belly and the dorsal and anal fins.. As with so many eelpouts, their lifestyle is incompletely known.

Elusive fish, with a tendency to live in deep waters, the specific habitats and behavior of eelpouts, such as spawning times and places, are always difficult to determine. Laboratory studies are important, for here at least behavior can be more readily observed. Occasionally it is possible as well to view the long slender fish in an aquarium setting. This is a rare opportunity, and for the most part, these fish will always remain hidden from view. New species may be identified, but as with so many fish of deep waters, what transpires in their lives remains in the realm of mystery. Meanwhile, this successful family moves north and south, adapting to the availability of the rich resources of the planet's coldest seas.