

Hell on Earth: Life in the Hadal Zone



Figure 1 A scale diagram of the aquatic layers.
Benjamin Stein.

It was once theorised by naturalists Edward Forbes and Henry Godwin-Austen that no life could exist below the depth of 300 fathoms below the sea surface. Indeed, it seemed that in the crushing pressures and dark waters half a mile down there could be no possible chance of surviving life, and for nearly two decades after Forbes and Austen dredged the Aegean for life in 1841 this Azoic Theory persisted.

As more evidence was gathered, we have found that life still flourishes not only at 500m below the surface, in what is now the higher regions of the mesopelagic zone, seen in (Figure 1.), but deeper still, past 1000m in the bathypelagic, and further still, below 4000m in the silent, lightless abyssopelagic zone. It can seem incredible that at these crushing pressures, devoid of light and nutrition life can still exist beyond the form of extremophile bacterium, which use chemical vents to create the building blocks of life. However, deeper still is the hadopelagic zone. Named for Hades, the shadowy land of the Greek underworld, this zone exists only in narrow trenches carved into the sea floor, from 6000m to a staggering 11000m.

In the depths of the hadopelagic zone, pressure reaches over 1000 atmospheres, the temperature is a consistent 4 degrees Centigrade and sunlight has long since vanished. These unfavourable conditions make it a great challenge to reach and research the Hadal Zone, and we still know near nothing about the species here, even though it totals an area equal in size to Australia. Our entire understanding of the Hadal is based on 4 expeditions and surveys, and even they did not provide much conclusive evidence about life in the Hadal. So how do organisms survive at this kind of depth? A habitat of extreme isolation and endemism, the species living in hell have developed incredible adaptations.

Monstrosities in the Deep

The Chimera was a creature of Greek mythology, a gruesome mixture of lion, goat and snake, fused together into a fire breathing monstrosity that struck fear into the hearts of ancient civilization. In the Hades of the deep sea, found at around 5000-7000 metres, is the best known predator of the lightless ocean, the sea devils. Sea Devils are a specific type of anglerfish, from the family Ceratiidae, from the Greek 'horned', and are found across the world, in tropical and Antarctic waters alike.

These deep sea hunters are true biological chimera, a single organism made from the cells of different zygotes. This phenomena has been recorded in many species, including humans, where twins have absorbed each other in the uterus and part of the offspring is actually made from a different organism. Where the anglerfish differ is in that they are the only species that purposely seeks to become a mixture of single beings, slowly losing their individuality from their partners and becoming little more than flesh and blood, drifting silently through the Hadal, linked until death.

When specimens of this species were first dredged up from the deep ocean, ecologists and biologist were baffled as to the lack of male individuals found to be captured. Indeed, all of the creatures that they brought to the surface were female, warty brown skin, voracious needle teeth and the famous luminous lure suspended from the front of the face. Even stranger were the tumorous attachments growing from the sides of the females, seemingly serving no purpose. Nearly a century later, in the 1920s, biologists captured a female specimen with two smaller fish attached to her belly by their mouths. A member of the Natural History Museum, Charles Tate Regan, then the Keeper of Zoology, and later the director of the museum dissected these smaller fish and discovered that they were the same species as the female.

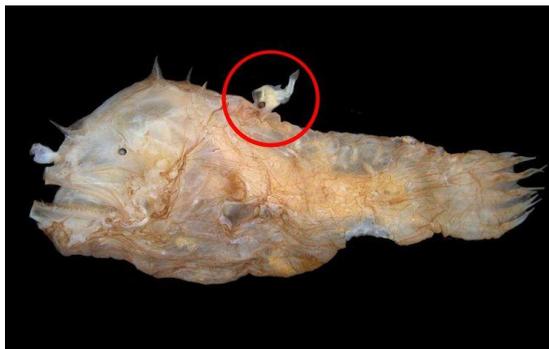


Figure 2. Sea Devil. The male bites into the female's back to begin their fusion. www.reed.edu

The anglerfish has enormous sexual dimorphism: the males tiny and utterly without the ability to hunt, have found a bizarre way to solve the problems of living in a vast, uninhabited void, where encounters with a member of the opposite sex are rare. Once mature, the tiny male uses an acute sense of smell to locate the nearest female and bites into her belly (Figure 2.) Once there the male releases enzymes that dissolve both of their bodies and fuse their blood streams together. Atrophy of the features

ensues, the male loses his eyes, nose, mouth and fins, becoming little more than a parasitic gonad, which the female can use for reproduction as she needs to. The pair will stay like this until they die, the male totally dependent on the female for the rest of what can only be described as its existence.

As the prominent marine biologist of the time, Charles William Beebe, said, 'to become a brainless, senseless thing that was a fish – this is sheer fiction, beyond all belief unless we have seen some proof of it.' This is the kind of incredible lengths that species must go to in order to survive in the darkness.

A Light in the Shadows

Like the dreary realm of Hades, the Hadal Zone is a world devoid of colour and sound. It is almost impossible to imagine such a place, unable to hear or see, with only the cold oppressive darkness pushing in from all sides. Communication as we know it becomes impossible, hunting as fish would in shallower waters is no longer viable. To combat this problem, species of the dark abyss have developed their own light - bioluminescence.

From the Mesopelagic zone downwards, nearly all species are capable of producing their own light, through the use of tiny symbiotic bacteria, or by reacting chemicals called luciferins inside their own body. Away from the harsh glare of the sun, the organisms of the deep sea are blissfully protected from ultra-violet radiation and the damage that it inflicts on our bodies on a daily basis. The UVB photons found in sunlight are capable of fusing thymine base pairs within our body, doing damage to our genetic code, and making it impossible to copy. Antioxidants such as luciferins can fix this damage; but without a need for such repairs this new use was found for the spare chemicals.

Almost every problem caused by the pitch black environment that these species live in is solved by their flashing displays. Prey can be lured into striking range, or the target can be illuminated. A confusing flash of luminescence can distract a predator; or a gaudy light-show could draw in larger predators, capable of threatening the original hunter, as is the case with the vibrant Alarm Jellyfish (Fig 3.) It is little surprise that the Hadal Zone is just as rife with glimmering animals as the rest of the ocean.

Viperfish are some of the most common in the upper hadopelagic zone, using their unique photospheres to communicate with potential mates and other hunting viperfish, before seizing smaller prey like lanternfish with their long immobilising maws. While on the hunt, the darkness of their habitat is a great help, turning off their lights and waiting, motionless, like a sinister assassin, for prey to drift past them in the inky blackness.

Jellyfish also make great use of the shimmering chemicals in their body, and their bizarre alien forms can be seen drifting serenely through the depths, leaving mesmerising trails of bright light flowing behind them. Strangely, the red and orange light that many deep sea jellies produce is totally invisible to the eyes of most other sea life, allowing them some limited vision and communication that most of their predators cannot detect. Divers and underwater photographers at lower depths also use red lights, as it allows them to see the animals they are searching for without disturbing or frightening them.



Figure 3 An alarm jelly flashes to attract larger predators. Credit: michaelaw.com

In a world with no sun or stars, where everything is a blanket of perpetual unnatural night more shadowed than anything we can conceive, light is the ultimate bringer of life in the Hadal Zone. Almost all species there require it to see, hunt and speak. As it is so succinctly put by biologist Edith Widder, 'In the ocean, bioluminescence is the rule rather than the exception'.

Over the Edge

The Mariana Trench is the deepest marine trench in the world at 11000m - so large that Mount Everest would fit into it comfortably. Challenger's Point is at the Mariana's base, and is the lowest point on earth, the home of the lowest animals, known collectively as benthos. These creatures live a slow life of fierce scavenging for the few scraps of food that can be found, for at such depths supporting a body capable of hunting is nigh on impossible.

Crawling in the muck of the sea floor, these animals rely entirely on the detritus and debris from the pelagic zones above them, pieces of dead flesh and vegetation, often microscopic in size, which drift down and keep these organisms alive. This marine snow comes all the way from the richer waters of the epipelagic zone.



Figure 4. Supergiant amphipod specimen.
Credit: © Oceanlab, University of Aberdeen

Sifting through the slimy sediment the benthos include the sea cucumber and flatworms, which use tiny mouthpieces to filter through the remains of other organisms' lunches in order to extract the life giving nutrients. Supergiant amphipods (Figure 4), crustaceans of 10 inches in length dart about the sand looking for larger debris. The sightings of such animals are few and far between, some coming at 100 years apart; with only seven specimens ever caught.

Perhaps the strangest creature that has been found at such depths is a new variety of xenophyophores, peculiar amoebas that live in extremely deep sea areas. Unlike ordinary cells, this single celled organism is up to 10cm in diameter, colossal considering the size of the cells that we use in our body, which have to be viewed with the aid of a lens. Buried deeply in the sand of the sea bed, this extremophile probes out with alien pseudopods to absorb the scraps that drift down.

Lower than light's touch, lower than the black billowing vents of chemical cascades that provide for tube worms, lower even than the sea bed itself; these animals are the true lowest of all creatures, forced to extraordinary lengths just to find their next meal.

A world of infinite shadow, complexity and challenge, no other creature on the earth must contend with the same conditions as the denizens of Hell itself. Under the pressure of 11000m of ocean and at near freezing temperatures, the most bizarre, ferocious, vivid and tenacious creatures in existence dwell: pressed into evolutionary diamonds by their crushing environment. Daily adversity sharpens these organisms against the dangers of the cold dark abyss with every new generation becoming stronger, quicker and stealthier in the fight to survive. It is certainly true with such creatures that what doesn't kill you, only makes you stronger. If Hell exists, it is here, 6000 fathoms below the water.

Bibliography

The HADES Project for Hadal Zone Research (<http://web.who.edu/hades/>)

The University of Aberdeen's Hadal Zone Studies

The Schmidt Ocean Institute - Mark Schrope (<http://schmidtocean.org/cruise/exploring-the-mariana-trench/>)

LiveScience News - Wynne Parry (<http://www.livescience.com/19318-bioluminescent-light-organisms.html>)

fishbase.org