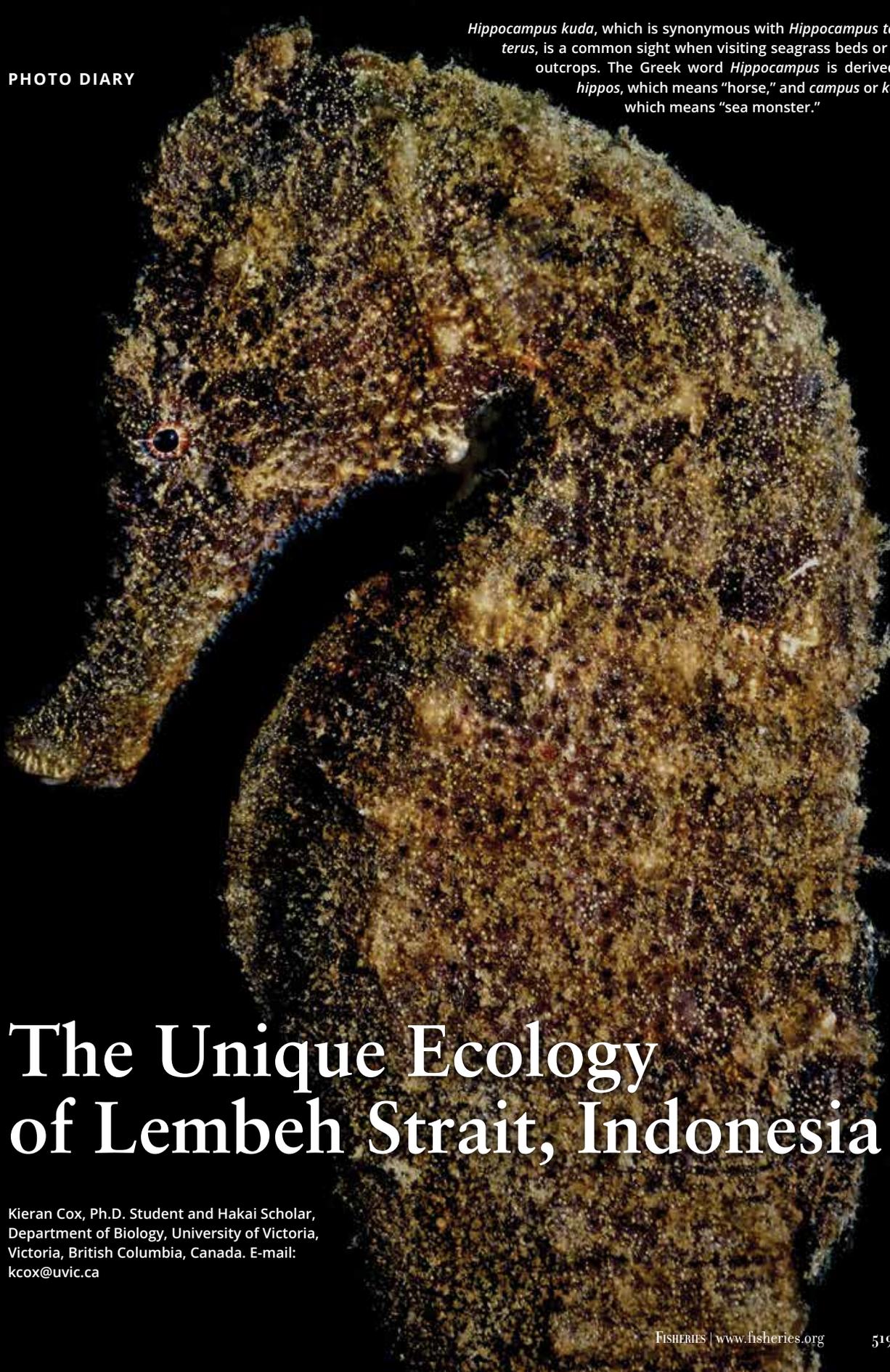


PHOTO DIARY

*Hippocampus kuda*, which is synonymous with *Hippocampus taeniop-  
terus*, is a common sight when visiting seagrass beds or rubble  
outcrops. The Greek word *Hippocampus* is derived from  
*hippos*, which means "horse," and *campus* or *kampos*,  
which means "sea monster."



# The Unique Ecology of Lembeh Strait, Indonesia

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Sulawesi is an island located in Indonesia, west of the central Pacific Ocean, where the southern seas meet the Indian Ocean and is one of the 18,000 islands that make up the Indonesian archipelago. Routed between Sulawesi and Lembeh Island in the province of North Sulawesi lies the Lembeh Strait. This 15-km-long, 2-km-wide, narrow strait is less than 120 ft at its deepest point and is comprised almost entirely of black volcanic sand and rocky outcroppings, the result of numerous active volcanoes in North Sulawesi. With a population of 200,000, the city of Bitung sits on Sulawesi and supports extensive shipping, large coconut plantations, rice fields, and other industrial activities. The combination of a surprisingly active shipping port, extensive marine debris, which is an increasing issue throughout Indonesia and surrounding nations, and striking black volcano sand sets the Lembeh Strait apart—especially in comparison to the rest of the country, which boasts some of the most diverse and productive coral reefs in the world. What makes the strait exceptional, however, is not world-renowned coral diversity or seemingly endless species of fish for which Indonesia is known—it is the unique ecology of the species that can survive and thrive within this unique ecosystem.

The Lembeh Strait is one of the premier muck diving locations in the world, which, as the name suggests, involves diving among the “muck” or, in this case, black sand. Originally coined by Bob Halstead when diving in Milne Bay, Papua New Guinea, muck diving has quickly become a favorite for those hoping to catch a glimpse of rare and unusual marine life. In this regard, the abundance of extraordinary species within the strait seems to be endless, with some species that divers may go their entire careers and never encounter being common sightings.

Certain groups of species tend to do better within the strait, likely due to their life histories and ecological niche requirements. The family Syngnathidae, which includes the seahorses and pipefishes, appear to be one of these groups. Breeding pairs of seahorses are a common sighting among the sparse eelgrass, pipefishes are known to take refuge within the coral that has managed to grow in the strait, and multiple pygmy seahorses, no bigger than a fingernail, may occupy a single fan coral. Another notable group and common reason why underwater photographers visit Lembeh is the numerous species of frogfishes that reside within the strait. These anglerfishes are a member of the genus *Lophiiformes* and are most commonly known for their impeccable camouflage and remarkable “fishing” behavior. These fishes can be seen waving their illicium, a long filament protruding from their heads with a fleshy growth known as the esca on it, much like a fly-fishing rod. The wiggling of the esca lures in the anglerfishes prey, making an ambush attack imminent.

In terms of species diversity, one of the sheer wonders within the strait are the nudibranchs. Indonesia is one of the foremost locations in the world for its nudibranch diversity, and the strait is no exception. Ecological strategies seem to unfold before your eyes when observing this diverse group. Mimicry seems to be a common phenomenon; discerning the differences between species is nearly impossible to the untrained eye. Species exhibit exceptional aposematism, as brightly colored nudibranchs warn would-be predators, and disruptive coloration causes certain species to seem almost too obvious unless viewed in the appropriate context.



*Corythoichthys flavofasciatus*, is commonly known as the Network Pipefish, Reticulate Pipefish, or Yellow-banded Pipefish. This individual was one of a mating pair. Much like their seahorse relatives, *C. flavofasciatus* form monogamous pairs with obligate and genetic mating being observed; the male *C. flavofasciatus* is also known to carry the eggs in a brood pouch.

(Right) *Hippocampus bargibanti* or Bargibant's Seahorse, with a maximum length of almost 2.7 cm, is the largest of the pygmy seahorses. Living exclusively on fan corals, *H. bargibanti* was discovered by Gilbert Whitley in 1970, making it the first species of pygmy seahorses to be formally described.

(Below) *Antennarius striatus*, appropriately referred to as the Hairy Frogfish, is covered with dermal spinules that resemble hairs. Much like other frogfish, *A. striatus* has the capacity to change its coloration and pigmentation within a few weeks to better match its environment. The result is that *A. striatus* within Lembeh Strait are extremely well suited for the sargassum seaweed that surrounds them.





*Antennarius maculatus*, the Warty Frogfish, is effectively named after the wart-like protuberances that cover its body. With its large prognathous mouth, *A. maculatus* is capable of consuming prey similar to its own body size. They are also known to “yawn” as a display of aggression.

Not surprisingly, cephalopods are another class of species that have done exceptionally well within the strait. Although it is not uncommon to have an abundance of cephalopods within an area, it is the diversity and life histories for those within the strait that is unforgettable. The mimic octopus *Thaumoctopus mimicus*, which was first discovered in Sulawesi, is known not only for its ability to change its skin color and texture to camouflage with its environment but its ability to change body shape and behavior to imitate marine species. Mimic octopuses have been observed imitating dozens of species, including lionfish, flatfish, jellyfish, and even sea snakes. Although much smaller than the mimic octopus, one of the most venomous marine species in the world can often be found hunting in the rubble throughout the strait. With a maximum size of 8 in and an incredibly docile nature, the blue ring octopus *Hapalochlaena* sp. doesn't seem like much of a threat unless provoked. If threatened, over 50 iridescent blue rings appear on the dorsal and lateral surfaces of the mantle as a warning to would-be predators. To date, four species of *Hapalochlaena* have been confirmed and research is ongoing into six additional species; the extent to which of these species can be found within the Lembeh Strait is still unknown. The strait is also home to one of the most extraordinary octopus in the world, the coconut octopus *Amphioctopus marginatus*, which is known for its unique tool use and bipedal walking. Lodging itself inside coconut husks or empty bivalve shells, it buries into the sand to avoid predators. With an abundance of shells, husks, and, unfortunately, marine debris, the coconut octopus can often be found running along the substrate, buried in a discarded beer bottle, or peeking out from behind a coconut fortress. There is little doubt that cephalopods

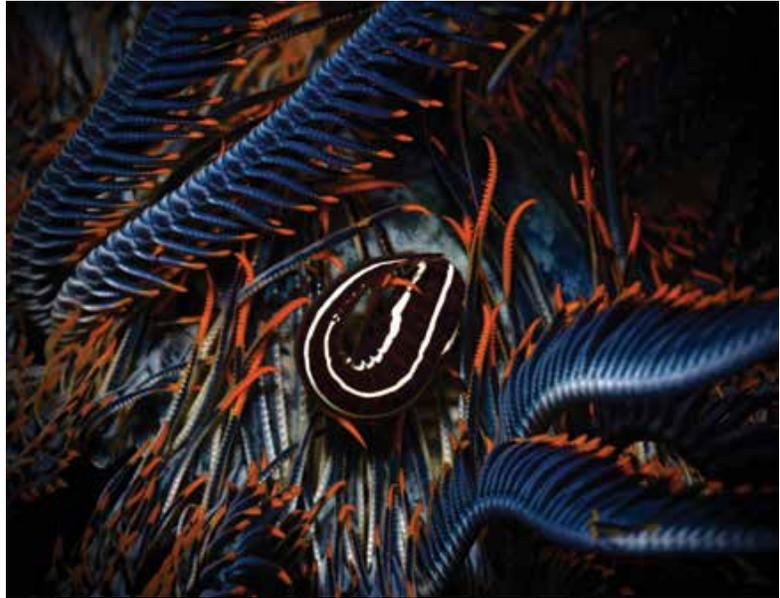
are one of the most adaptive groups of marine species, and their complex behaviors, problem-solving ability, and effective hunting skills have made them well adapted to live in the strait. Lembeh Strait also houses numerous other species, including countless species of cuttlefish, the starry night octopus *Callistoctopus luteus*, and even the hairy octopus *Octopus* sp.; the latter is currently undescribed.

The immediate question that follows a visit to this area is, what makes Lembeh Strait capable of supporting such rare species, at densities found at only a few other places in the world? Various theories have surfaced, including those surrounding the nutrients supplied by the black volcanic sand. In my opinion, to determine what makes Lembeh so unique, you have to consider the species within it, their life histories, and the nature of the strait. The ecology of Lembeh has evolved not despite the lack of coral, which is commonly the foundation of any diverse tropical marine ecosystem, but because of it. The black sand, although unique, makes the strait essentially a barren wasteland compared to reefs in the surrounding waters and ensures that species who rely on coral are unable to colonize the area. However, species who have “alternative” life histories not directly dependent on coral reefs would flourish within an area like the Lembeh Strait. Species that carry around coconuts for shelter, sit motionless in the rubble and “fish” for their next meal, or spend their entire life living on a single fan coral are able to thrive within this otherwise barren wasteland. Further study is needed to confirm this theory and is essential to deepen our understanding of these ecosystems, the species that reside within them, and whether the unique ecology of this area stands to be protected.

(Top) *Discotrema crinophilum*, the Crinoid Clingfish, is only found among the arms of crinoids, particularly *Comanthus bennetti*. It is not uncommon to find a crinoid crab and crinoid shrimp occupying the same crinoid. Little is known about this fish, with basic information on population numbers and life history still lacking.

(Center) *Chromodoris willani* is named after the infamous nudibranch taxonomist Richard Willan. This individual was taking refuge on a single-use water bottle, a depressing and unfortunately all-too-common sight within Indonesian waters.

(Bottom) *Ardeadoris cruenta* is appropriately named after the notable red spots on its upper dorsum. The Latin word *cruentus* means "stained with blood."





*Phyllidia varicose*, has a wide native range that includes the Indo-West Pacific Oceans, the central Pacific, and the Red Sea. It is not surprising that numerous species, including juvenile sea cucumbers, mimic *P. varicose* with the aim of convincing predators that they are also poisonous.

Although unprovoked attacks from the blueringed octopus *Hapalochlaena* sp. are extremely rare, the tetrodotoxin released if bitten is 1,200 times more toxic than cyanide, with no existing antivenom.



*Thaumoctopus mimicus*, or the mimic octopus, was discovered off the coast of Sulawesi in 1998 and formally described in 2005 by Mark Norman and Eric Hochberg. *T. mimicus* is most known for its ability to imitate a diverse range of species in order to elude predators.

*Sepia bandensis*, more commonly known as the Stumpy-spined Cuttlefish or Dwarf Cuttlefish, has a maximum mantle length of 7 cm and is commonly seen walking along the substrate as it hunts small fishes and crustaceans.



*Amphioctopus marginatus*, the notorious coconut octopus, is known for its unusual behaviors, including bipedal walking and tool use. An analysis of the former highlighted that this species is capable of walking on two of their eight arms while the other six arms are drawn up and surround the body and, as such, is the first example of bipedal locomotion using a hydrostatic skeleton rather than rigid support, published in *Science* by Christine Huffard, Farnis Boneka, and Robert Full in 2005.

Kieran Cox is a Hakai Scholar and Ph.D. student at the University of Victoria, studying under the co-supervision of Dr. Francis Juanes and Dr. Sarah Dudas. His graduate research is a collaborative effort between the Hakai Institute, the Juanes Lab, Ecological Interactions Research Program and seeks to investigate how marine biodiversity varies across different habitats and the processes driving this variation. As an avid underwater photographer and scientific diver with the Canadian Associate of Underwater Science, Kieran has been fortunate enough to dive and work in numerous locations including Christmas Island (Kiribati), Honduras, Australia, and through the Pacific Northwest. These pictures were taken during Kieran's third trip to Indonesia and second time in the Lembeh Strait. During which he enjoyed staying and diving with Divers Lodge Lembeh, situated on 25 hectares of tropical nature reserve land at the southern end of Lembeh Island.

