current

THE JOURNAL OF MARINE EDUCATION

Volume 30 • No. 2 • Fall/Winter 2016

A Case Study in Exploration: A Tiny Fish with a Big Name Sets the Hook into Grades 4-5 Ocean Literacy

BY ANNE KRAUSS AND MICHAEL LOMBARDI

ABSTRACT
For nearly two decades, a mesophotic exploration program in the Bahamas has emphasized the value of human intervention (via deep technical diving) within that ocean environment. A recent notable success was the discovery of a new mesophotic clingfish *(Derilissus lombardii)* (Sparks and Gruber 2012). An educational resource article chronicling this discovery was developed for small group instruction, allowing students to access current marine research and acquire domain-specific academic vocabulary. Literacy instruction focused on applying decoding skills and comprehension strategies to informational text features. This collaboration between the fields of ocean exploration and literacy intervention provided grades four and five general education and special education students access to real-world science experiences and complex informational texts. This work represents a case study in this unique collaboration.

INTRODUCTION

Literacy specialist Anne Krauss had always been motivated and inspired by the ocean, but when she tried to share her passion with the reluctant readers on her caseload, she found few engaging texts at their reading level. She knew her students were innately curious about the ocean, but lacked access to real-world science experiences, so she set out to acquire and create resources about current marine research, marine careers, and ocean exploration.

Visiting the Sea Grant Marine Careers website, she found explorer Michael Lombardi's profile and emailed him with her interest in learning more about marine science. In 2011, he responded with an invitation to a life-changing encounter and a closer look in to his field: swimming with blue sharks. This experience catalyzed a collaboration which brought the frontiers of diving exploration into the elementary school classroom. The collaborators regularly and routinely shared anecdotal field experiences and scientific data through electronic means, with the goal of developing ocean literacy curriculum.

One single discovery in particular, the collection of a new species of mesophotic clingfish *(Derilissus lombardii)*, amplified the collaborative efforts to develop resources to engage students more directly with this type of exploration and its discovery potential. The educator-explorer partnership has increased student motivation and interest in reading nonfiction text for enjoyment. Several students have demonstrated continued interest in marine science topics and an ability to apply literacy strategies to independent learning. This fusion of language arts and science encouraged students to become curious and independent learners through continued application of literacy skills that unlocked self-selected topics of interest.

Student Inquiry and Exploration

Fourth and fifth grade students at Cobbles Elementary School in Penfield, New York studied the *Derilissus lombardii* discovery as part of a close reading unit that bolstered decoding skills and nonfiction reading strategies. These students, identified for intervention services in language arts, applied their developing literacy skills to a content area unit that closely followed current marine science fieldwork and advances in ocean exploration. This pullout supplemental instruction was provided in a Title 1 public school where instructional autonomy allowed for the creation of an interdisciplinary collaboration while still meeting the academic needs of students reading below grade level.

The *Derilissus lombardii* discovery was shared with students through photographs, discussion, and excerpts from the blog on the Ocean Opportunity Inc. website. Scaffolded vocabulary instruction focused on scientific and technical terms, as well as affixes and Greek word roots. After reading texts about coral reefs and building on students' knowledge of ocean habitats, the concept of mesophotic coral ecosystems (MCEs) was introduced through photographs of the actual fieldwork (see image in sidebar on page 26). Guided Science Talks (Expeditionary Learning 2013) prompted students to think like scientists and discuss guiding questions: Have we discovered all there is to know about our planet? What do we still need to learn? How can we learn it?

continued on page 27

EXPLORING THE DEPTHS

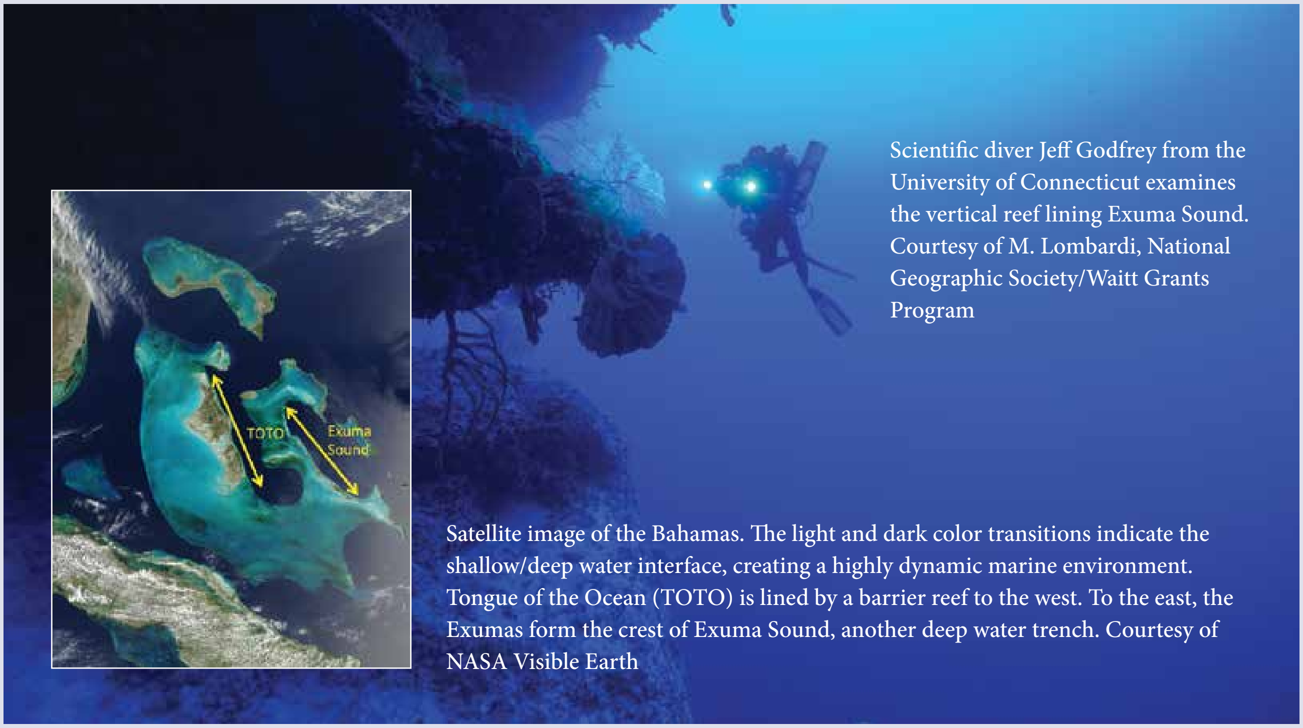
Discovery of the *Derilissus lombardii* resulted from the author's expertise in mesophotic coral ecosystems (MCEs), a recent international priority in the ocean sciences (Puglise et al. 2009). Encompassing depths of 200 to 500 feet of seawater (fsw), the MCE depth range is conventionally considered too deep for manned scientific diving, yet too shallow to substantiate the expense of manned submersibles or undersea robotics. Therefore, MCEs are vastly overlooked, yet have revealed promise in providing opportunities for new biotechnological discoveries, novel biodiversity, and clues into global climate change. Follow-on protection and management of these yet-to-be-discovered ocean resources is the reason for exploring this range more extensively.

The author's expedition team has made incremental advances in scientific diving technology and demonstrated cost-effective, efficient, and safe operations throughout MCEs for nearly two decades. Previous fieldwork in Exuma Sound, Bahamas using methods for mixed-gas, open-circuit SCUBA (Lombardi ed. 2002) proved valuable but inefficient, with only minutes spent at target working depths to 300fsw/90msw (Lombardi 2003). Subsequent work in the Tongue of the Ocean (TOTO) and again in Exuma Sound refined protocols at increased depths with safe and productive results to 446fsw/136msw (Lombardi 2011; Lombardi and Godfrey 2011). The design and experimental deployment of a portable decompression habitat (Lombardi et al. 2013) successfully enabled further range extensions and a focused human-based mesophotic exploration regime using new technology.

These critical advances established the technical capability to effectively work in unexplored environments where discoveries were likely to be made. They also inspired informative outreach mechanisms through web and social media conduits which ultimately resulted in the collaboration described here.

Discovery of a New Species

Collection of the *Derilissus lombardii* was the result of scouting ideal target sites along the vertical fore-reef and further establishing multiple rotenone stations, followed by collection of cryptic fishes that were teased from small cracks within the coral reef. *Derilissus lombardii*, named for the fish's collector, was described by Sparks and Gruber (2012), and is presently in repository at the American Museum of Natural History.



Scientific diver Jeff Godfrey from the University of Connecticut examines the vertical reef lining Exuma Sound. Courtesy of M. Lombardi, National Geographic Society/Waitt Grants Program

Satellite image of the Bahamas. The light and dark color transitions indicate the shallow/deep water interface, creating a highly dynamic marine environment. Tongue of the Ocean (TOTO) is lined by a barrier reef to the west. To the east, the Exumas form the crest of Exuma Sound, another deep water trench. Courtesy of NASA Visible Earth

continued from page 25

Students viewed photos of vertical MCEs and divers working at mesophotic depths, and brainstormed what might be found through firsthand exploration using the Observe-Wonder-Infer strategy (Gear 2008). To develop inferential comprehension skills, students viewed photos of divers at depth and answered: What do you observe? What do you wonder? What do you infer? Using clues from the photos and their own background knowledge, students made inferences. This process revealed students' thinking and misconceptions. A previous lesson on aquaculture influenced some of the fourth graders' comments ("Food—scientists are trying to make food under the water"), while other students tried to apply their understanding of light and ocean zones: "He's in the midnight zone! It's dim wherever he is, and that's far from the sunlight zone, I think. You can see how it's getting darker and darker and darker."

Sparking Interest Through Firsthand Accounts

The theme of ongoing learning and discovery was applied to student inquiry. Curiosity and access to real-life science motivated developing readers and writers, many of whom have never visited the ocean. Using excerpts, photos, and captions from the Ocean Opportunity Inc. blog, students gained access to anecdotal experiences in the field. The narrative nature of the discovery process was particularly interesting to students, specifically, the idea of finding and classifying a new species, which prompted several student questions. Email exchanges between the explorer and the educator provided further details about the *Derilissus lombardii* discovery. After learning about *Derilissus lombardii*, a fourth grader wanted to write about the discovery for a current events assignment and share it with her class. She attempted to conduct online research independently, but could not find a detailed, accessible text at her reading level. A peer-reviewed scientific journal article describing the fish's taxonomy was available in *Copeia* (Sparks and Gruber 2012), but the abstract alone was written at a collegiate level. Portions of the original article were used instructionally to model how adults apply Close Reading strategies and persistence to tackle challenging texts. Instruction focused on identifying unknown words and concepts, text coding, and rereading multiple times to enhance comprehension.

Adapting a Peer-Reviewed Scientific Journal Article

Responding to student interest, the instructor drafted a student-friendly version of the *Copeia* article. Students generated further questions about exploration and *Derilissus lombardii*, and emailed them to the explorer. They were thrilled to receive serious responses from someone in the field. This communication validated the students' questions and motivated them to focus on spelling, syntax, and clarity in their writing. It modeled how scientists and educators apply literacy skills to convey important ideas about their work. Furthermore, student inquiry and the explorer's responses influenced the student-friendly article's content.

Complex texts covering complex scientific issues naturally lend themselves to critical thinking. The adapted article continued to emphasize the importance of future exploration and environmental conservation, while targeting students' deficit skills in decoding and vocabulary. Student feedback forms were collected after reading revised drafts, indicating responses to basic comprehension questions, student-identified challenging words, positive feedback, suggestions for improvement, and areas of further interest. Running reading records and readability measures ensured that the text was written at an appropriate level for the students. Scientific and technical input added veracity, resulting in a motivating, high-interest complex text that introduced students to a crucial marine environment while targeting their weaknesses in decoding (challenging vowel patterns, multisyllabic words, and word roots), vocabulary, and nonfiction comprehension. Scaffolded Close Reading instruction focused on the importance of rereading, identifying the gist, and reader identification of domain-specific vocabulary. Text coding allowed students to delve into the text, making connections and formulating questions. Students revisited the article over several sessions and shared new understandings.

Demonstrating Student Learning

Using firsthand accounts, such as the blog and email as primary source texts, students learned about the physical demands and challenges of manned diving exploration. They also learned about the human health implications of obtaining natural products from the ocean depths for medical research and discussed the ethical questions surrounding the removal of endemic species for study. Students were introduced to the idea that even small discoveries can provide clues to coral health, population balance and range, and climate change. After responding to literal comprehension questions about the discovery, students completed a graphic organizer that demonstrated the potential impact of the *Derilissus lombardii* discovery (see Figures 1 and 2 on page 28). The organizer represented the "ripple effect" that new discoveries might provide.

In their written responses, students demonstrated a beginning understanding of conservation, as well as the value of new ecological understandings, advances in technology, and the need for continued exploration. After learning about the new fish's distinguishing external features, one curious fifth grader wanted to study the fish in greater detail and wondered about the *Derilissus lombardii's* blood type and internal organs, as well as the implications of marine research for human health. This thirst for knowledge typified increased student motivation and initiative.

In addition to written notes and graphic organizers, students created new species identification posters using details from the fieldwork (see Figure 3 on page 29). Students generated and recorded questions about the discovery process, and one fourth grader wrote her own current events article and gave a presentation to her class.

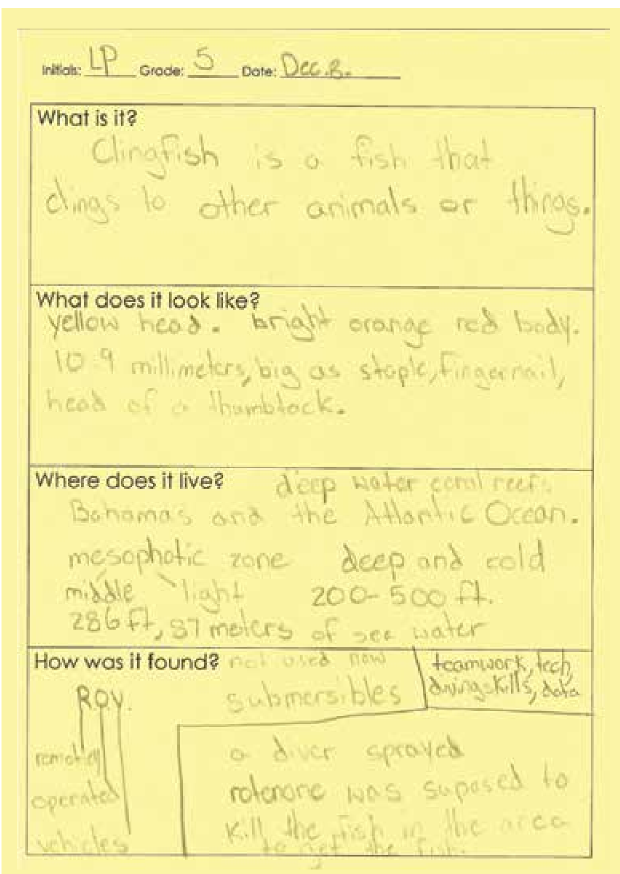
CONCLUSION

The continuing collaboration intends to creatively integrate science and language arts, encourage engagement, cultivate motivation, and inspire curiosity. Engaging future generations of explorers with technical concepts requires ocean literacy tools which inspire not only the pursuit of marine and ocean science, but critical thinking about humanity's role on our planet. High-interest, accessible texts based on real-world discoveries nurture students' natural curiosity and support developing readers. This explorer-educator partnership can be replicated to engage learners in real-world, real-time content through instructional approaches and additional student-friendly resource articles that can be implemented in small or large groups. (See pages 31-33 for more ideas on how to incorporate "Ocean Literacy Resource: *D. Lombardi* Discovery" in the classroom.)

Continued discoveries require that future explorers perceive today's extreme environments: MCEs, the deep ocean, Mars and beyond, as attainable. Pursuing these frontiers is essential to maintaining the spirit of exploration inherent in our humanity.

MORE RESOURCES

- photo on National Geographic
- IUCN Red List profile
- Fishbase.org profile
- Dl on the tree of life
- Wikispecies citation


Initials: LP Grade: 5 Date: Dec. 8.

What is it? Clingfish is a fish that clings to other animals or things.

What does it look like? yellow head. bright orange red body. 10.9 millimeters, big as staple, fingernail, head of a thumbtack.

Where does it live? deep water coral reefs. Bahamas and the Atlantic Ocean. mesophotic zone deep and cold middle light 200-500 ft. 286 ft, 87 meters of sea water

How was it found? not used now submersibles teamwork, tech, diving skills, data ROV remotely operated vehicles a diver sprayed rotenone was suposed to kill the fish in the area to get the fish.

FIGURE 1. Student notetaking form. Courtesy of A. Krauss

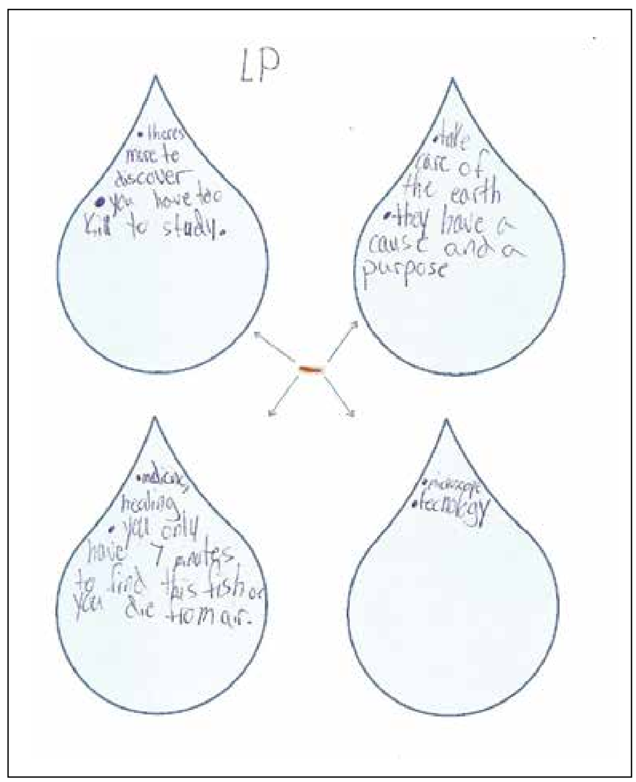


FIGURE 2. Student graphic organizer showing water drops that represent the "ripple effect" and implications of new scientific understandings. Courtesy of A. Krauss

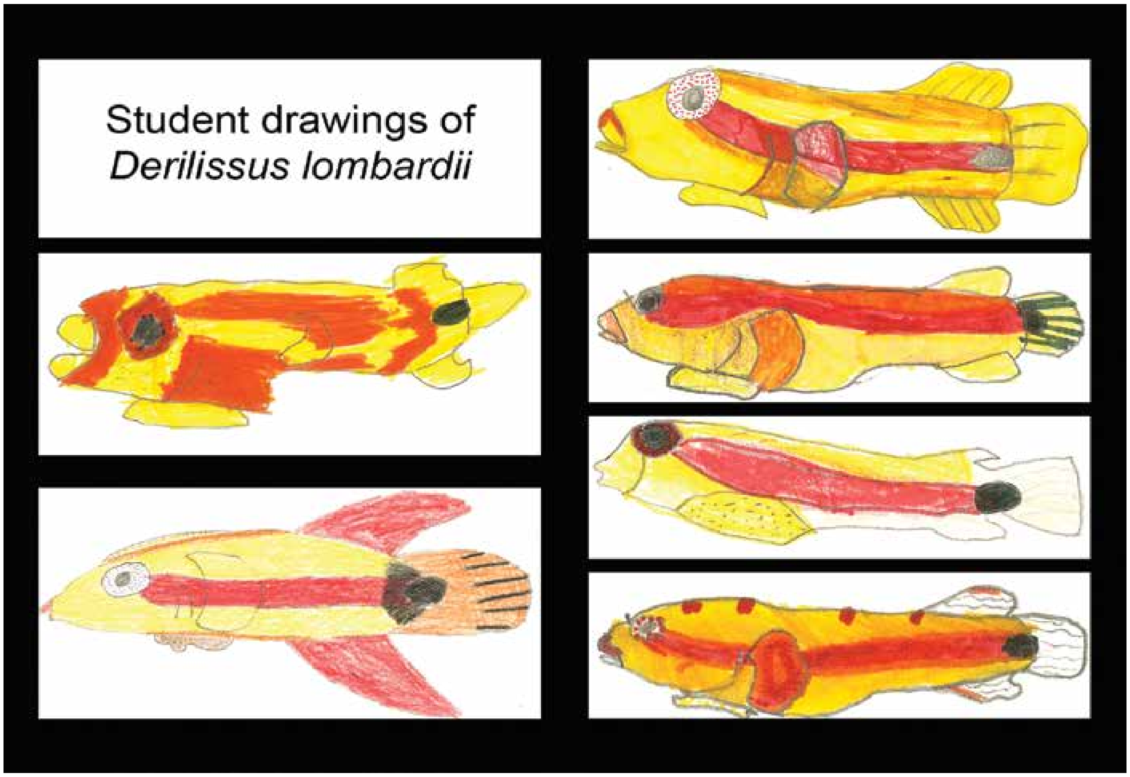


FIGURE 3. Fifth graders studied the fish's unique features and made inferences about how it might use those features to survive in a mesophotic environment. Courtesy of A. Krauss

REFERENCES

Gear, A. (2008). *Nonfiction Reading Power: Teaching Students How to Think While They Read all Kinds of Information.* Ontario, Canada: Pembroke Publishers.

Krauss, S. (2016). *Derilissus lombardii* (Line drawing). Adapted from *Derilissus lombardii*, described in *Copeia* (Sparks and Gruber 2012).

Lombardi, M.R. (ed. 2002). The Next Step: Mixed Gas Technical Diving 'Science 300 feet deep' Procedures for diving operations using mixed-gas, open-circuit SCUBA with staged, in-water decompression for conducting undersea science exploration. *PIMS-CMRC/NOAA-NURC* internal document. 33 pp.

Lombardi, M.R. (2003). Considerations for scientific technical diving: An overview of logistics, procedures, and implications for program development. *'Diving for Science 2003' Proceedings of the 22nd Annual American Academy of Underwater Sciences Symposium,* pp. 43-58.

Lombardi, M.R. (2011). A Visual Profile of the Vertical Mesophotic Coral Ecosystem of the Tongue of the Ocean (TOTO), Andros, Bahamas to 100 meters. *Proceedings of the 2011 American Academy of Underwater Sciences Annual Symposium,* pp. 9-12.

Lombardi, M.R., and J. Godfrey. (2011). In-water strategies for scientific diver based examinations of the vertical Mesophotic Coral Ecosystem (vMCE) from 50 to 150 meters. *Proceedings of the 2011 American Academy of Underwater Sciences Annual Symposium*, pp. 13-21.

Lombardi, M.R., W. Burleson, J. Godfrey, and R. Fryburg. (2013). An Experimental Deployment of a Portable Inflatable Habitat in Open Water to Augment Lengthy In-Water Decompression by Scientific Divers. *Marine Technology Society Journal: Diving Technologies & Techniques for the 21st Century*, 47(6): 52-63.

NASA Visible Earth. Satellite image of Bahamas. Credit Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC. Data date: May 18, 2001. Visualization Date: February 17, 2003.

National Geographic Kids. Map of the Bahamas. http://kids.nationalgeographic.com/explore/countries/bahamas/#Bahamas map.png. Accessed March 3, 2016.

New York State Education Department. Grades 3-8 ELA Curriculum: Appendix 1: Protocols and Resources. https://www.engageny.org/resource/grades-3-8-ela-curriculum-appendix-1-protocols-and-resources. Accessed November 2, 2015.

Puglise, KA, L.M. Hinderstein, J.C.A. Marr, M.J. Dowgiallo, and F.A. Martinez. (2009). *Mesophotic Coral Ecosystems Research Strategy: International Workshop to Prioritize Research and Management Needs for Mesophotic Coral Ecosystems.* NOAA Technical Memorandum NOS NCCOS 98 and OAR OER 2. 24 pp.

Sparks, J.S., and D.F. Gruber. (2012). A New Mesophotic Clingfish (Teleostei: Gobiesocidae) from the Bahamas. *Copeia*, 2012(2): 251-256.

ACKNOWLEDGEMENTS

The exploration described within this paper was funded by National Geographic Society Waitt Grants Program Award W140-10 to ML, and Ocean Opportunity Inc., with technical support from the Perry Institute's Caribbean Marine Research Center on Lee Stocking Island. The authors thank the American Museum of Natural History and the City University of New York for their taxonomy efforts, as well as support from their home affiliations of Cobbles Elementary School and Lombardi Undersea LLC. Thanks to Julie Kirkwood for her independent review and editing assistance.

ANNE KRAUSS has been teaching language arts for 17 years. Growing up on Lake Ontario and the St. Lawrence River, she has always been fascinated by what lies beneath the water's surface. As a literacy specialist, she fosters children's natural curiosity about the ocean and its intriguing inhabitants to motivate K-5 readers and writers to acquire and apply literacy skills in the context of ocean exploration and ocean literacy.

MICHAEL LOMBARDI has been living 'the life aquatic' since age 16, and through several thousands of hours personally spent underwater, he has championed new and emerging technologies and techniques for human exploration while advocating improved ocean literacy through these experiences and resulting discoveries. Michael co-chairs the Diving Committee of the Marine Technology Society, and has received multiple grant awards from the National Geographic Society for his work in ocean exploration.

OCEAN LITERACY RESOURCE: THE *DERILISSUS LOMBARDII* DISCOVERY

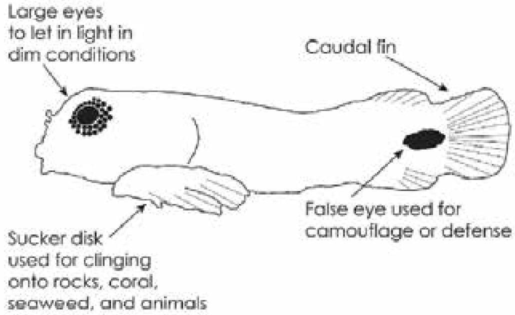


FIGURE 4. (left) *Derilissus lombardii*, described in *Copeia* (Sparks and Gruber 2012). (right) Line drawing prepared for student instruction. Courtesy of S. Krauss

Imagine that you are diving a few hundred feet beneath the ocean's surface. A steep, rocky wall looms in front of you. The wall's vertical path fades into darkness below you. You cannot see the bottom. In the dim light, the jagged wall seems endless.

You are not only seeing this strange environment for the first time in your life, you are also surrounded by unusual sea life that has never been seen by human eyes. In fact, you may be the first person in history to explore this part of our watery world.

Although you'd like to stay longer, your visit must be brief. You must save enough time, air, and energy to return safely to the surface. How will you share your mesmerizing experience in the mesophotic (mĕ-zō-fō-tĭk) zone with the rest of the world? By taking photographs and collecting samples of the many interesting things that you've seen.

Studying your samples needs to wait. Though you took only a brief journey—less than 10 minutes at the deepest point—the return trip to the surface is the hard part, lasting several hours. Why the wait? Being hundreds of feet underwater puts the human body under immense pressure. You must ascend very slowly to get used to pressure back at the surface.

Once you finally examine your samples, you realize that one find is truly unique. You may have discovered a new type of fish!

There's a New Fish in Town

On May 4, 2011, a team of researchers did just that, and discovered a new species, or type, of fish. It turned out to be a new type of clingfish. Clingfish use sucker disks on their underside to attach themselves to coral reefs, rocks, seagrass, and even larger fish (see Figure 4). The fish was studied at the American Museum of Natural History and given a scientific name: *Derilissus lombardii*. The name is literally longer than the fish! *Derilissus* tells us that it is a type of clingfish. It was named after Michael Lombardi, who was the first person to ever see and collect this animal.

Derilissus lombardii makes its home in warm, tropical water. Unlike most well-known fish that live in shallow-water coral reefs, this clingfish was discovered on a deep reef in the Bahamas.

FIGURE 5. Map of the Bahamas. From National Geographic Kids

Small but Mighty

With a yellow head and a bright orange-red body, you might think the flame-colored fish was hard to miss. However, it was found in a small crack on the reef in 286 ft of seawater (87 m). This is more than twice the maximum diving depth of sport divers.

This dainty discovery measured 10.9 millimeters. That's about the width of a fingernail, or the length of a staple.

When most people think of ocean creatures, they may think of huge whales, large sharks, or other big animals. The ocean is vast, but even the smallest citizens of the sea can teach us a great deal.

Scientific discoveries do not have to be huge in size to make an impact. Some discoveries, like *Derilissus lombardii*, may be small in size, but big in importance. Even the tiniest organisms, like plankton, bacteria, and algae (ăl-jē) play a giant role in keeping the ocean balanced, colorful, and healthy!

In the Middle

The *Derilissus lombardii* specimen was found along a rocky vertical underwater wall in the darker mesophotic, or middle light, zone (see Figure 6). There isn't as much light as near the surface, or photic zone, but it's not as dark as the aphotic zone.

Shallow-water coral reefs can be reached using regular SCUBA diving equipment, but deep water reefs have not been studied as much because they are harder to reach. To explore these deeper ecosystems, researchers and inventors had to find new and innovative ways to use diving technology.

Mesophotic coral reefs are found at depths between 200 to 500 ft. In the big picture of the ocean's depths, this is not very deep. However, it is deep enough to require highly trained and experienced divers who need to use special diving equipment to reach these areas safely. Even then, they cannot stay at these dim depths for long. They must work quickly to gather images and samples to study later.

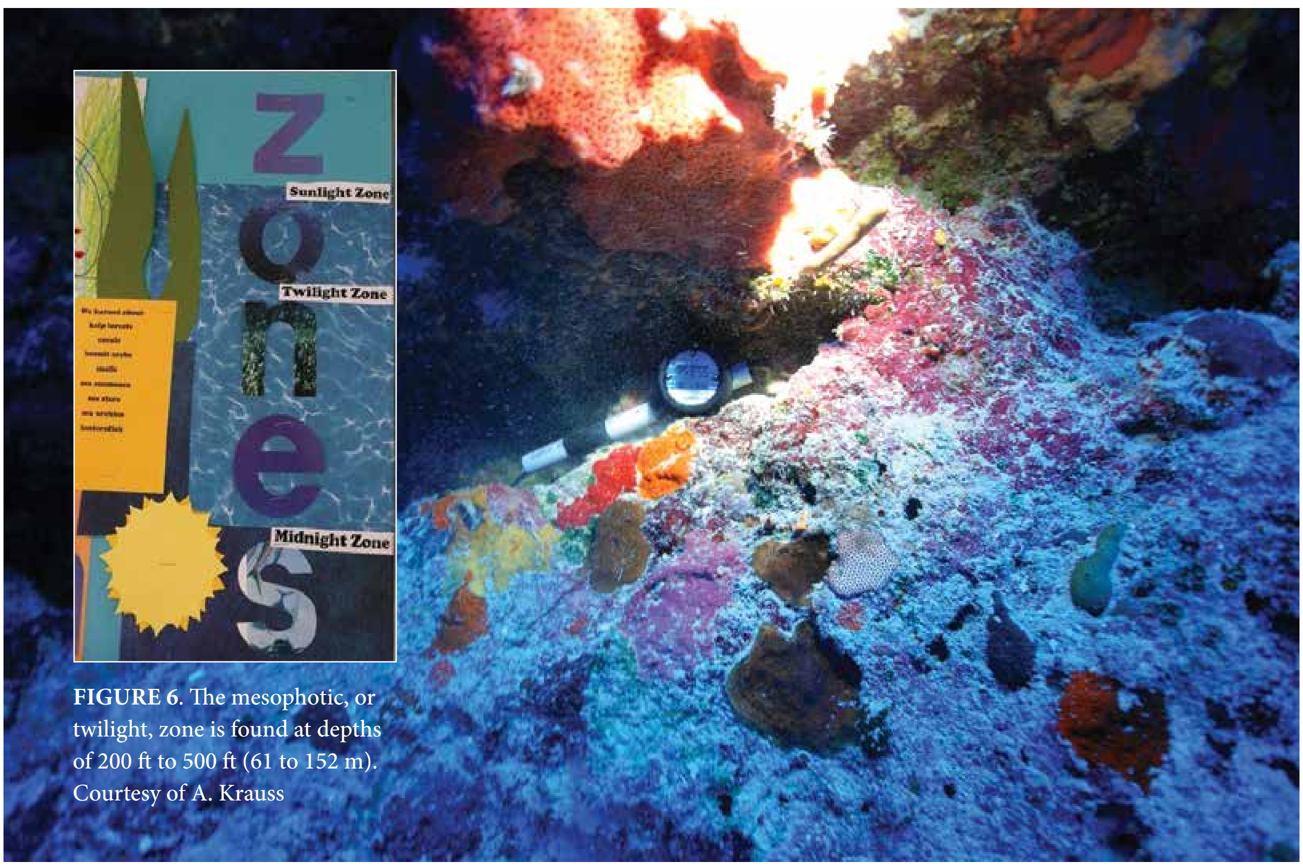


FIGURE 6. The mesophotic, or twilight, zone is found at depths of 200 ft to 500 ft (61 to 152 m). Courtesy of A. Krauss

Along the vertical reef face, biodiversity is incredibly high. Here we see more than a dozen benthic invertebrates. Hidden within the cracks and crevasses are cryptic fishes and eels that make up an as-yet discovered population. Courtesy of M. Lombardi

Deep divers need to work well under pressure—both water pressure and time pressure. They must be focused and quick-thinking. Deep dives like this challenge both their bodies and their minds.

To reach deeper areas where divers cannot go, scientists must use underwater remotely operated vehicles (ROVs) and submersibles to explore.

Go Fish!

Unlike fish and marine mammals, humans were not designed to move and breathe underwater. We must get help from tools and technology. Wetsuits keep divers warm and protected. Fins are worn on the feet to make swimming easier and more effective. Masks are worn to see better. To breathe underwater, divers must use special equipment to carry breathing gases.

Beneath the surface, the increasing water pressure limits how deep we can dive. The deeper the depth, the greater the pressure. Most SCUBA divers who are diving for fun can only reach about 130 ft (40 m). Some divers can go deeper because they have the technology, equipment, training, skills, and experience to reach deeper depths safely.

Teamwork and Technology

A team of experts combined their skills and knowledge to make the *Derilissus lombardii* discovery. They used teamwork, technology, and special diving skills to collect data, images, and samples that will help us learn more about this rather undiscovered part of our world. They continue to work hard to improve diving and research methods in order to safely reach depths that few people have explored.

Compare and Contrast

The *Derilissus lombardii* was collected during a series of research dives. To prove that the fish was indeed a new type of fish, scientists studied it closely and carefully. They took detailed photographs and measurements and compared them to similar types of clingfish.

Like other clingfish, the new fish had large eyes and a sucker disk. Scientists looked for differences, and found that this one was special. Some differences were easier to see, such as its pale yellow head and the black oval spot near the base of its tail. Other differences required a microscope. Tiny bumps on the sucker disk were arranged in an unusual crescent pattern. These tiny differences proved that the fish was a new species.

Diving Deeper

If a new species of fish could be discovered in less than 10 minutes, what other discoveries might be made with more exploration time and better access to deep reefs? Researchers are fishing for answers. Similar research missions have revealed some of the ocean's secrets. What secrets might the ocean hold? New plants and animals—the keys to improving human health, such as treatments for cancer and other diseases.

Exploration can also provide information about the Earth's health, including the effects of pollution on animal populations. Could these answers lie just a few feet deeper? The ocean still holds many secrets. These researchers hope to unlock more secrets through further research and exploration. They are limited only by the ocean's accessibility, not their curiosity.

Protecting our oceans from pollution, overfishing, and climate change can help keep ecosystems healthy and in balance, which preserves the opportunity for future discoveries. Every tiny discovery reveals a piece of the ocean's big puzzle.

KEYWORDS

Ascend: to go up

Specimen: something collected as a sample or for examination

Ecosystems: communities of plants and animals that depend on the same environment

Technology: the use of science to solve problems

Submersibles: small vehicles designed for underwater work or exploration

Crescent: a curved shape that is thicker in the middle and has two narrow pointed ends

current
THE JOURNAL OF MARINE EDUCATION

NATIONAL MARINE EDUCATORS ASSOCIATION
c/o Jeannette Connors
4321 Hartwick Road, Suite 300
College Park, MD
20740

INSIDE current

Volume 30 • No. 2 • Fall/Winter 2016