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MONTESSORI & ENVIRONMENTAL STEWARDSHIP

A school incorporates marine science into the curriculum.

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Environmental Stewardship Promotes a Sense of Place: Coral Health Monitoring on Maui

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Environmental stewardship is an integral aspect of the Montessori curriculum. It usually includes care of the school's setting (classrooms, grounds, gardens, eating areas, etc.) and, depending on each school's unique situation, ideally extends into the larger environment in which the school is situated. Activities such as school landscaping, gardening, nature walks, and outings increase awareness of local environmental concerns and teach that environmental stewardship is much more than pulling weeds and picking up trash.

Through the Montessori cosmic curriculum, students learn not only to recognize the interdependence of living things but also come to realize that living things depend on the inorganic world. Environmental stewardship is meant to help students develop a consciousness of their place on Earth, with respect to their roles in protecting our planet's resources and future habitability; with that consciousness, they can extend understanding into action.

Environmental stewardship often takes the form of community service, a typical component of Montessori school programs, especially at the Secondary level, where it is a natural fit with the adolescent's developmental need for independence and desire to make a difference in the world while participating in projects or activities that are also personally meaningful. Through giving of their time to a variety of local efforts, students become shareholders in their community and begin to recognize that their contributions are important.

During the 2014–2015 school year, Middle School students at Montessori Hale O Keiki (MHOK), a small, AMS-accredited Montessori school on Maui's south shore, were asked to select community service projects directly relevant to environmental and/or ecological issues on Maui. Participation in beach cleanups and invasive-plant removal at a significant

Hawaiian archaeological preserve/wetlands refuge both brought about a deep sense of personal satisfaction, but the students' yearlong participation in the Coral Watch program (more about this later) truly

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"instill[ed] both the values of cultural and environmental stewardship with hands-on, student-centered research and critical skill development needed for success in 21st-century careers" (MHOK, 2015).

MARINE AND ENVIRONMENTAL STEWARDSHIP PROGRAM—BACKGROUND

Much of the surrounding environment of Montessori Hale O Keiki is *mauna* and *kai* (mountains and ocean); as a result, there is a strong marine science component to the school's curriculum. In 2009, MHOK received a Schools of the Future (SOTF) grant from the Hawai'i Community Foundation and the Hawai'i Association of Independent Schools. Through the support of the SOTF grant, the school hired Raquel, a naturalist, to assist teachers in developing a robust marine science curriculum focusing on 21st-century skills—leading MHOK to be recognized as "the state of Hawai'i's only Marine Science School of the Future... incorporating Marine Science into all classrooms" (MHOK, 2015) and naturally integrating its environmental stewardship component into both indoor and outdoor marine science activities. And while the hallmarks of MHOK's marine science program are the snorkeling (Upper Elementary) and scuba diving (Middle School) components, environmental stewardship is the hub around which the program revolves.

In 2008, MHOK's first class of Middle School students "piloted an inquiry-based oceanic sciences program, where students were scuba-dive certified, enabling them to conduct underwater research" (MHOK, 2015). Each year, Middle School students receive training and certification in open-water scuba diving through the Professional Association of Diving Instructors (PADI):

The PADI System of diver education is based on progressive training that introduces skills, safety-related information, and local environmental knowledge to student divers in stages. PADI courses are student-centered and provide maximum practice and realistic application. (PADI, 2015)

Our students begin by studying PADI's *Open Water Diver Manual*, on which they are later tested. The manual covers basic diving topics and techniques, such as choosing, using, maintaining, and storing equipment; basic training, from pool to open-water diving; diving physiology, including buoyancy, behavior of gases, decompression sickness, and hypothermia; dive planning; decompression dives; and safety and first aid. The second phase of training involves practicing with a mask, snorkel, fins, regulator, buoyancy control device, and a tank in contained water (a pool). Finally, when the students have mastered the contents of the manual and the use of dive equipment in the pool, they are ready to practice their skills in the open ocean and eventually to conduct underwater research for any number of inquiry-based marine science projects.

Upper Elementary students engage in task-oriented underwater research while snorkeling, the skills for which are first practiced in a pool and then in the open ocean. While there is no special certification for snorkeling, these outings train Elementary students in water skills and increase their comfort and confidence in the open ocean, preparing them to progress to scuba diving in Middle School.

A PLACE-BASED CURRICULUM

A study of marine science on Maui (or on any island, for that matter; islands are fragile ecosystems) necessitates a look at the bigger picture, as the oceans do not exist in isolation but in relation to other important features of the environment—mountains and volcanoes, flora and fauna, and, of course, Hawaii's people and history. Although the emphasis shifts from year to year, these aspects of the islands, both geographical and cultural, are threaded into as many curricular areas as possible, with the ocean as the point of origin for units of study.

Because MHOK is a relatively small school (60–75 students, depending on the year), its Upper Elementary and Middle School students are combined in one classroom (usually 16–24 students)—which MHOK refers to as its "Upper School"—with a head teacher responsible for coordinating the entire fourth- through eighth-year curricula. Specialists take over significant areas for Middle School students; for example, there is a literacy specialist for language arts and a naturalist for science. Raquel has a master's degree in marine science with a specialization in

biological oceanography; she teaches marine science to all levels, from Early Childhood to Middle School.

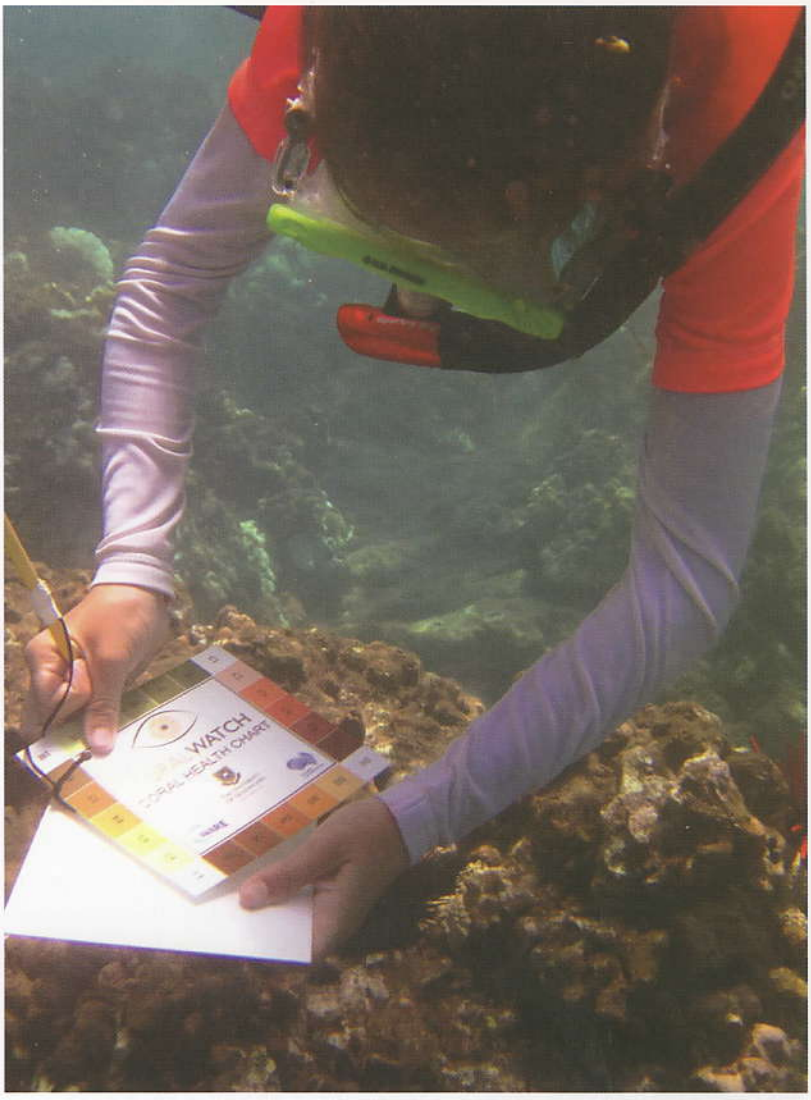
While Upper Elementary and Middle School lessons are kept separate, there can be some overlap of subject areas. For example, Middle School students may explore similar or related topics at a more sophisticated level, then come back to present their research to the Upper Elementary students. The younger students not only gain exposure to more information but also get a preview of the level of work they will be involved in when they reach Middle School. Furthermore, this type of peer teaching helps to reinforce the knowledge of older students, promotes confidence, and strengthens community among different levels of students.

THE *AHUPUA'A*—FROM THE MOUNTAIN TO THE SEA

MHOK's Upper Elementary students began the 2014–2015 school year with a study of the *ahupua'a*—the method by which ancient Hawaiians divided the land:

Shaped by island geography, each ahupua'a was a wedge-shaped area of land running from the uplands to the sea, following the natural boundaries of the watershed. Each ahupua'a contained the resources the human community needed, from fish and salt, to fertile land for farming taro or sweet potato, to koa and other trees growing in upslope areas. Villagers from the coast traded fish for other foods or for wood to build canoes and houses. Specialized knowledge and resources peculiar to a small area were also shared among ahupua'a. (Hawai'i History, 2015)

While the ahupua'a as a theme provided obvious lessons and extensions in island geography, natural resources, history and culture, mythology, and Hawaiian vocabulary, the takeaway message was really one of environmental stewardship. Students learned that the use of natural resources was carefully managed through a system of *kapu* ("forbidden"), enforced by *konohiki* and *kahuna* (priests), who regulated, for example, what species of fish could be harvested during which seasons, or which plants could be harvested and when and how they needed to be replaced. Students grasped the value of the ahupua'a as a self-sustaining unit and learned to appreciate the elders' emphasis on "the interrelationship of elements and beings... [and the incorporation of] those interrelationships in the activities of daily and seasonal life" (Hawai'i History, 2015). Several field trips throughout the year to the sites of ancient Hawaiian villages and archaeological preserves not only helped solidify student understanding but brought to life many of the concepts explored in their ahupua'a study.



An Upper Elementary snorkeler compares coral bleaching to the Color Watch coral health chart (Ulua Beach, Maui).

Although the ahupua'a unit was largely the work of Upper Elementary students, our Middle School students extended the concept to modern society, asking, "Who are the konohiki and kahuna for Maui today?" This led naturally to an investigation of who makes the rules, places restrictions, and makes decisions about how our natural resources are utilized and protected in the larger world. Middle School students explored these questions through researching the roles of the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the Division of Aquatic Resources, the Hawaii State Energy Office, the Department of Land and Natural Resources, and the Fish and Wildlife Service. Following the thread, students continued with an investigation of specific environmental issues on Maui, such as renewable energy, the growing of genetically modified organisms, wastewater disposal, sugarcane burning, and the handling of invasive species. To fine-

Upper Elementary snorkeler showing the Coral Watch color chart (Ulua Beach, Maui)

tune the research, students next focused on marine-specific environmental issues—overfishing, pollution, and climate change, with the related consequences of ocean acidification, ocean warming, and sea-level rise. From the big picture to the small, this research inspired the Middle School students to dedicate their yearlong marine science project to an investigation of the health of Maui's coral, especially given the effects of climate change on coral health.

Hands-on data collection in the open ocean provided meaning and relevance at a level that made this project a transformative experience.

THE CORAL WATCH PROGRAM

The Coral Watch program, based at the University of Queensland, in Australia, provides participants with a noninvasive method of monitoring the health of corals based on their color, which is an indicator of the degree to which coral bleaching has occurred (Coral Watch, 2015). Bleaching, our students learned, occurs as a stress response to one or more of the following conditions: warmer ocean temperatures, due to global warming; reduced available sunlight, due to sea-level rise and/or an increase in sedimentation; and/or ocean acidification, due to excessive carbon dioxide in our atmosphere and our oceans. When coral is stressed for any reason, its essential zooxanthellae (mutualistic photosynthetic algae) are forced to leave, causing its "bleached" white appearance. The colorful algal partners provide the coral with oxygen and most of its nutritional needs, through photosynthesis; help the coral to remove waste; and give coral its bright colors.

For our students, Coral Watch was the perfect project through which to integrate marine science, environmental stewardship, and community service into the curriculum. With a downloadable "do-it-yourself" kit, our Middle School divers learned a simple method to "quantify bleaching and monitor coral health" (Coral Watch, 2015): Measuring small fluctuations in the color of healthy coral is the key to identifying abnormal changes. Using an underwater slate, our student divers matched the color of a randomly selected coral with the colors on the slate and assigned a corresponding number. Later, back in the classroom, students uploaded this information to an online database, where it was analyzed by scientists in Australia for information on coral bleaching and recovery patterns.

Concurrent with collecting and contributing significant data for the Coral Watch program, students undertook an in-depth study of coral classification and anatomy, varieties and types of reefs, and coral's mutualistic zooxanthellae algal partners. In addition to studying the physical aspects of coral, students also investigated the ecological and economic importance of coral, discovering five main uses: 1) food—500 million people worldwide rely on fish that live in coral reefs, and $31 million is generated annually from worldwide fish sales; 2) habitat—corals not only provide habitat for a wide variety of fish and marine invertebrates but also provide areas for spawning, mating, and feeding; 3) tourism—places with healthy reefs earn hundreds of millions of dollars per year from tourist activities such as snorkeling and scuba diving; 4) medicine—coral reefs are important sources for ingredients in medicines to treat heart disease, cancer, poisonous stings, and burns and for general skin care; and 5) coastal protection—coral reefs provide stability to coastlines and protection against ocean storms and floods, and also help to slow down wave breaks and even tsunamis.

Middle School divers and a teacher investigate a loli okuhi kuhi *(black sea cucumber) (Molokini Crater, Maui).*

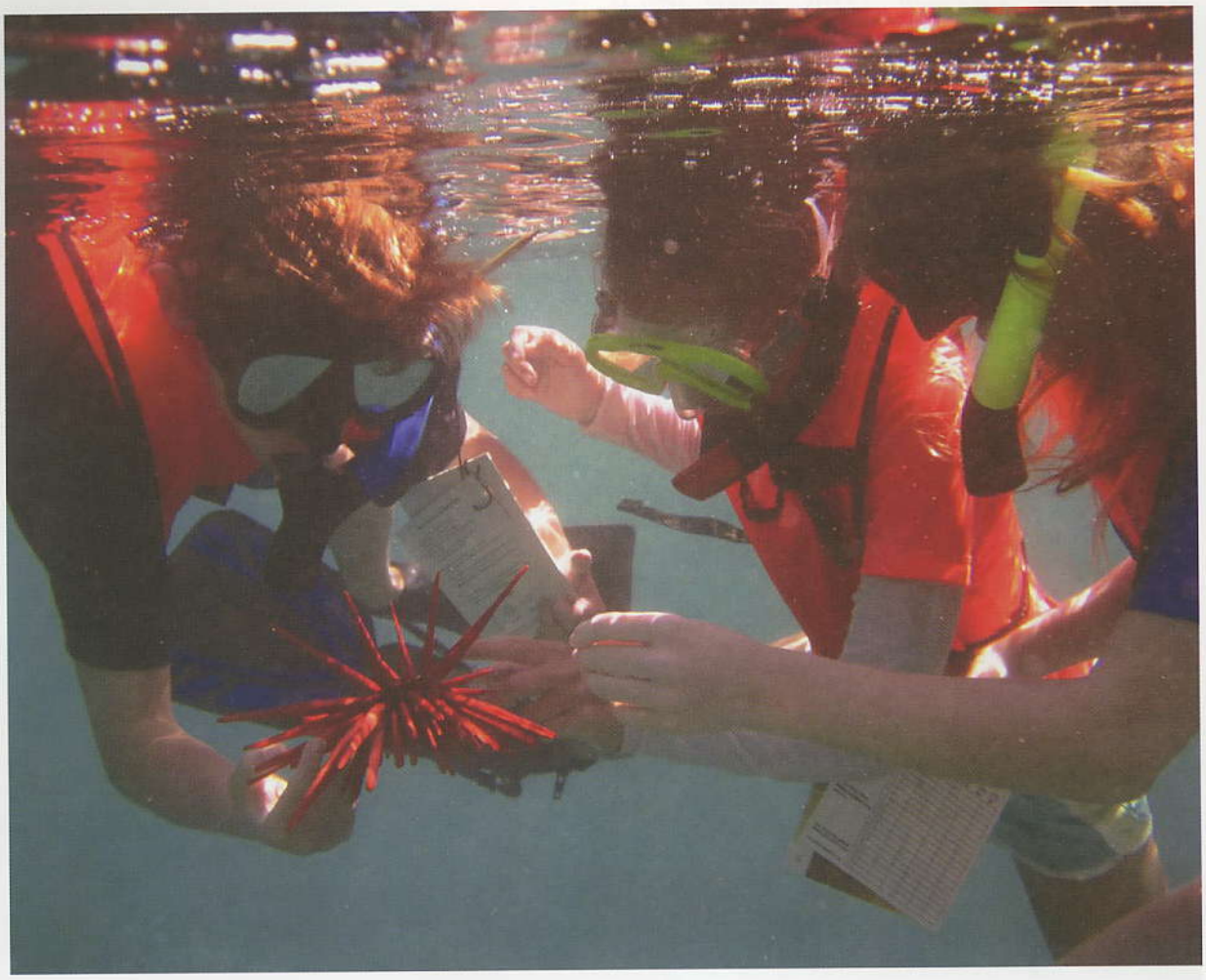
Most of the students' research, however, focused on the environmental factors—mostly consequences of climate change—that are currently contributing to the declining health of coral reefs worldwide. Students began with an examination of greenhouse gases (carbon dioxide, methane, nitrous oxide, fluorinated gases, ozone, and water vapor) and the extent to which both natural and anthropogenic factors affect levels of these gases in the atmosphere. Next, students identified the major marine environmental issues created by excessive greenhouse gases (ocean acidification, ocean warming, and sea-level rise); they defined each issue, discussed the causes, and illustrated the impact of each on coral health, especially with respect to coral bleaching.

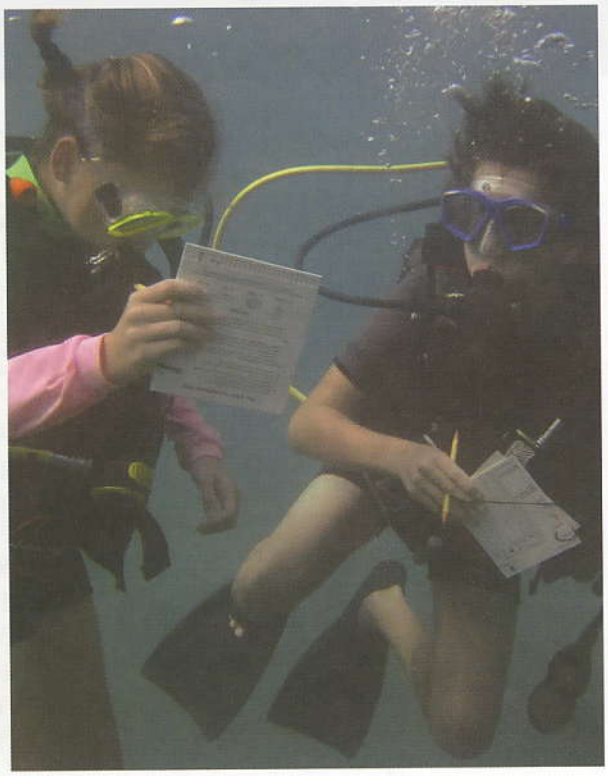
The classroom research was extensive and impressive in its own right, but the hands-on data collection in the open ocean provided meaning and relevance at a level that made this project a transformative experience, placing students at the intersection of experiential learning, research, and technology, as well as framing our school's sense of place.

As mentioned earlier, all the data collected by our student divers was uploaded to a global scientific database and is now part of a report that can be viewed on the "Map" page, found under "Data," of the Coral Watch website (Coral Watch, 2015). By clicking on the number over Hawaii, and on many of the links that then appear, our students' data from any one given outing can be viewed, sometimes with the name of the school attached and sometimes with a student's first name. Having their personal data collection published as part of a global environmental study is a powerful reinforcement of their hard work. Six of the nine reports from Maui were contributed by MHOK students; previous contributions were made by other divers in 2008, 2010, and 2011, giving our students additional data with which to compare their own results for evidence

Top: Upper Elementary snorkelers study a red-pencil sea urchin (Ulua Beach, Maui).

Bottom: Novice Middle School divers practice open-ocean dive skills (Makena Landing, Maui).





of changes in the health of corals, now and in the future.

Participation in the Coral Watch program was successful on a number of levels, not the least of which was the development and utilization of students' critical thinking skills. Students analyzed, for example, the difference in data between two beaches from which they collected information—one with coral exhibiting a higher degree of bleaching. They evaluated the data by hypothesizing reasons for more coral bleaching at one location—was this due to specific activity around each respective location (e.g., more or less tourism-related snorkeling and diving? New developments?), or was it related more to the type of coral that was sampled? Finally, students created a slide show—complete with discussion, diagrams, photos, graphs, and references—from their research and collected data. Critical thinking skills supported each step of this experiential learning process.

Students, staff, and parents attended the end-of-the-year presentation, and while students in the audience were impressed and excited by the information shared, adults were especially moved by the expertise,

articulation, and confidence with which the Middle School students presented their research and data. After so much personal investment—collecting data during open ocean dives, uploading data to a scientific database, researching myriad factors related to coral health, and compiling all their research into a presentation—these students, well-informed and passionate about their topic, were able to share their extensive work with self-assurance and pride.

RELATED MARINE SCIENCE PROJECTS

While our younger students mostly perform their environmental stewardship responsibilities on campus (aside from beach cleanup outings), their marine science work is foundational for future projects. Our Lower Elementary students, for example, are currently working on their own version of the Global Microplastics Initiative (Adventure Scientists for Conservation), a current undertaking to count microplastics in the world's oceans:

Microplastics particles, which are smaller than five millimeters in size, likely pose a massive environmental and human health risk when they enter our natural waterways…Our goal is to compile a comprehensive microplastics data set and use that information to effect change, turning off the inputs of microplastics pollution at their source. (2015)

Due to the requirements of the project, Raquel is collecting and submitting actual samples from local beaches; however, students are collecting their own samples to process and analyze in the classroom, mimicking the actual study as much as possible while gaining exposure to the process of scientific research as it is applied to at least one aspect of the natural world.

During another project, our Upper Elementary students collected data on a fish species of their choice during snorkel outings. As preparation for this work, students first learned about fish biology and anatomy through dissections of a bony fish (Osteichthyes) and a cartilaginous fish (Chondrichthyes). After choosing a fish common to Maui, students tallied their chosen fish's numbers during snorkel outings, using underwater slates, while also observing their fish's behavior and location in the water column. This research was then compiled into individual presentations in which each student discussed her/his fish's origins, locations found on Earth, diet, adaptations for defense and feeding, and other facts of their choosing.

In discussions about the differences in fish populations at various sites, students hypothesized that recent construction of a hotel near one of the sites may have contributed to sedimentation in that area, creating a less suitable reef environment for certain fish. Students also discussed the differences in population of some species in high-tourist areas versus a less-visited area, using higher-order thinking skills like analysis and synthesis to work out possible reasons for differences in their data; this is another example of experiential learning supported by critical thinking.

All science begins with careful observation and systematic data collection. By exposing our students and future community leaders to the process of scientific research, we hope not only to help them develop valuable skills, including critical thinking, but also to raise in them enough curiosity, interest, awareness, and concern that they want to learn about and take action toward addressing mounting environmental issues.

CONTINUING THE WORK

While this group of Middle School divers has since moved on, environmental problems contributing to declining coral health remain, and Coral Watch continues its important work. For the current school year, MHOK's Upper Elementary snorkelers join the new Middle School divers in collecting data for Coral Watch, thus increasing the number of reports from Maui on its data map. Additionally, a less-formal, local coral-monitoring program, Eyes of the Reef, is in place for

Upper Elementary snorkeler preparing to use the Coral Watch color chart (Ulua Beach, Maui)

PHOTOGRAPHY © MISTY PASCO

Top: Upper Elementary snorkelers identify an object of interest in a coral reef (Ulua Beach, Maui).

Bottom: Recording coral bleaching data (Ulua Beach, Maui)

Using the Color Watch color chart to assess coral bleaching (Ulua Beach, Maui)

volunteers to report cases of bleaching, coral and/or fish disease, crown-of-thorns sea star outbreaks, and other dangers (Eyes of the Reef, 2015). Raquel will report any cases observed by students, and this information will become a piece of the data being monitored by scientists at the Division of Aquatic Resources and the National Oceanic and Atmospheric Administration.

Through participation in Coral Watch, Eyes of the Reef, and the Global Microplastics Initiative, as well as in a variety of marine science classroom activities, our students are gaining exposure to skills associated with scientific research while working on important environmental issues and giving back to their community—a logical extension of the values associated with Montessori philosophy and education. And while learning about the health of Maui's coral and surrounding oceans, these students are making real, place-based contributions to vital scientific projects while conducting hands-on, student-centered research and developing critical thinking skills—all reflecting experiential learning, environmental stewardship, and Montessori at its best.

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RAQUEL HERNÁNDEZ, MS, is school naturalist at Montessori Hale O Keiki. In her 10 years as an outdoor science educator, she has covered, among other areas, forest/wetland ecology, snorkeling, scuba diving, sailing, marine science, and gardening. Contact her at raquel@mhok.org.

References

Adventure Scientists for Conservation. (2015). *Global microplastics initiative.* Retrieved October 2, 2015, from www.adventurescience.org/microplastics.html.

Coral Watch. (2015). *Monitoring sites.* Retrieved October 1, 2015, from www.coralwatch.org/web/guest/map.

Eyes of the Reef Hawaii. (2015). *Community reporting network for coral bleaching, diseases, COTS, and marine invasives.* Retrieved September 23, 2015, from www.eorhawaii.org.

Hawai'i History. (2015). *Ahupua'a.* Retrieved October 7, 2015, from www.hawaiihistory.org/index.cfm?fuseaction=ig.page&CategoryID=299.

Montessori Hale O Keiki. (2015). *School of the future.* Retrieved September 25, 2015, from www.mhok.org/index.php/academics/sotf.

Professional Association of Diving Instructors. (2015). *PADI courses.* Retrieved September 30, 2015, from www.padi.com/scuba-diving/about-padi.

Richardson, D. (Ed.). (2007). *Open water dive manual.* Rancho Santa Margarita, CA: Diving Science & Technology for PADI.