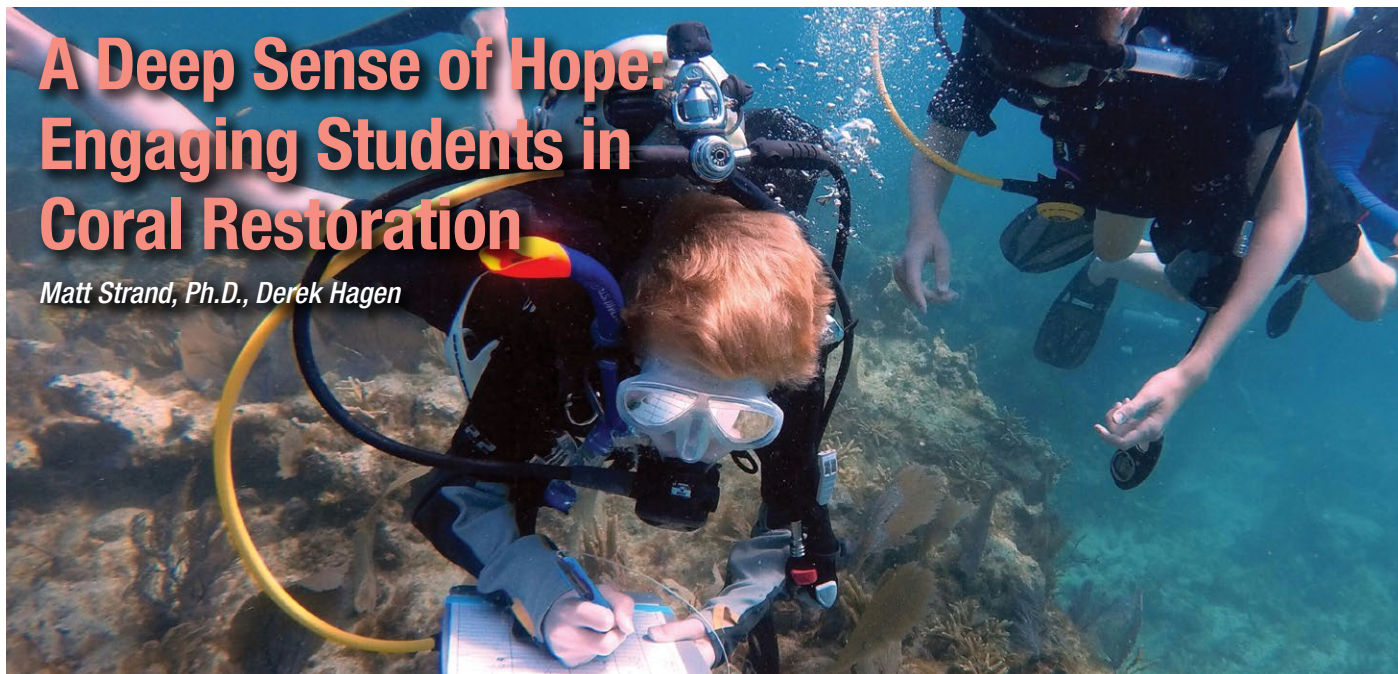


# A Deep Sense of Hope: Engaging Students in Coral Restoration

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## Abstract

This article describes a NOAA Planet Stewards Education Project where students dive deeply into environmental science and stewardship. The Colorado Coralition focuses on the science of climate change, coral decline, and reef restoration. Middle and high school students from Fort Collins, Colorado worked for an entire year to take part in the learning experience of a lifetime: helping the Coral Restoration Foundation in their efforts to stem the tide of coral reef decline in the Florida Keys. For the culmination of their 2019 project, Coralition students used their scuba diving skills to contribute to ongoing coral restoration research in an in-depth citizen science project at the bottom of the ocean.

Ryan and Larson, two 9th grade Polaris students, collect data on the health of out-planted staghorn corals at Carysfort Reef as part of the Colorado Coralition citizen science project.

Photo credit: Matt Strand

## An Introduction to Deeper Learning

Jaya, a 7th grader, hovers above a golden thicket of staghorn coral. Below her, purple sea fans wave softly in the current. She checks her regulator before sinking closer to the young corals clinging to the live rock substrate. She finds an algae-encrusted tag affixed to the coral and records the following data on her dive slate:

*Genotype: U 41*

*Cluster: 185*

Using her citizen science training, she counts the number of corals in the cluster and observes how many are alive and how many have fused with other coral fragments – both important indicators that out-planting efforts are succeeding on Carysfort Reef.

*Alive: 10*

*Dead: 0*

*Fused? Yes*

She swims over to Mikaela, her dive partner, who is monitoring another cluster nearby. They point enthusiastically to the positive data they have collected. Back on the dive boat, these two



**Figure 1.** Jaya assesses coral fragment survivorship at Carysfort Reef.

Photo credit: Matt Strand



**Figure 2.** Jaya and Mikaela compare their coral monitoring data at Carysfort Reef.

Photo credit: Matt Strand

middle schoolers are as exhilarated as the rest of the Coralition students in spite of this being their final dive before returning home to Colorado.

## Coral Decline in the Florida Reef Tract

The Florida Reef Tract is the third-largest barrier reef in the world, covering over 3,800 square miles (NASA, 2012). This expansive ecosystem is home to over 6,000 marine species (Florida Museum of Natural History, 2021). It provides vital coastal protection as well as a significant economic draw for recreation and tourism (NASA, 2012). However, the Florida Reef Tract has faced a precipitous decline in coral cover. Over the last 40 years, this reef system has lost approximately 97% of two of its most dominant shallow-water reef-building coral species: staghorn and elkhorn coral (Bruckner, 2002).

Climate change, the biggest threat to coral reefs around the world, is a primary driver of this decline. Thermal stress events from increasing temperatures cause coral bleaching and mortality. Additionally, global increases in CO<sup>2</sup> compound these stressors, causing the ocean to acidify, which results in severe degradation of coral calcification rates (NOAA, 2020). But there are regional contributors to the rapid decline of staghorn and elkhorn corals as well. The Florida Reef Tract's proximity to the southern Florida watershed has intensified the loss of native coral cover. Agricultural, urban, and suburban runoff results in a toxic blend of fertilizers, sewage, and pollution reaching this important ecosystem, resulting in catastrophic eutrophication and disease (NASA, 2012).

## The Coral Restoration Foundation

In Key Largo, Florida, the [Coral Restoration Foundation](#) (CRF), a nonprofit focused on reef conservation and recovery, is leading the charge to reverse this precipitous decline. CRF works to support the natural recovery processes of reefs around the world through the large-scale cultivation, out-planting, and monitoring of genetically diverse, reef-building corals. In Florida, this is accomplished by growing finger-sized elkhorn and staghorn corals in offshore nurseries. Corals are grown and harvested for out-planting in the wild on carefully selected out-planting sites. Once on-site, these

coral fragments are glued to the live rock substrate using a marine epoxy. Each out-planted coral is tagged with genetic, species, and location information for monitoring purposes. This allows CRF to identify genotypes that are resilient to the many global and regional threats to coral reefs. Since 2012, CRF has out-planted more than 120,000 critically endangered staghorn and elkhorn corals back onto the Florida Reef Tract. Many of these corals have now grown into thriving colonies with the ability to spawn, encouraging the reef's natural process of propagation.

Carysfort Reef is the northernmost of eight CRF out-planting sites in the Florida Keys. Much like the iconic lighthouse that sits atop this reef, Carysfort is a beacon of hope for coral restoration. At the close of 2020, CRF has out-planted over 35,000 new corals on Carysfort Reef. Active monitoring and data collection demonstrate an impressive 93% survivorship of staghorn and elkhorn corals at



**Figure 3.** A healthy cluster of elkhorn coral observed on Carysfort Reef.

Photo credit: Matt Strand



this site, as well as evidence of increased coral cover (Coral Restoration Foundation, 2019). CRF's success with reef restoration has drawn attention from all over the world, including a teacher and his students from Fort Collins who call themselves the Colorado Coralition.

## The Colorado Coralition

The Colorado Coralition (<https://spark.adobe.com/page/GreDo3zPQVV70/>) is a year-long environmental science project at Polaris Expeditionary Learning School (<https://pol.pedschools.org/>) in Fort Collins, Colorado. Polaris, a K-12 public school in Poudre School District, fosters learning through student-centered, standards-based projects that rely on experts, fieldwork, and real-world application. While Polaris teachers use this experiential project model in the day-to-day curriculum, they also develop week-long enrichment projects, called Intensives, that take place three times a year (in September, February, and in May). Intensive Weeks allow teachers a way to share passions beyond their content area with multi-age groups of students. Polaris students in 6th - 12th grade select their top "Intensive" choices from a menu of options. These experiences typically incorporate the arts, career exploration, adventure, technology, and/or service learning. Whether one teaches math, social studies, foreign language, or music, Polaris teachers are given wide latitude to create powerful learning experiences for kids. It is this invitation to innovate that led Dr. Matt Strand, the 7th and 8th grade English teacher at Polaris, to develop the Colorado Coralition. In 2013, Matt was awarded a grant from Fund For Teachers (<https://www.fundforteachers.org/>), which supported his efforts to earn his scuba certification and travel to Florida to volunteer with CRF. He participated in multiple dives, seeing firsthand the degradation on the Florida Reef Tract. It was a moving experience, one that gave him a blueprint for designing a similar life-changing opportunity for Polaris students. To make his dream of diving with students a reality, Dr. Strand designed the Coralition so the same cadre of students could participate in all three of his Intensive Weeks throughout the year.

### Scuba Certification

The middle and high school students selected to join the Coralition, which has a maximum acceptance of twenty students, start with rigorous study for their Open Water Certification. Divemasters from Colorado Scuba Diving Academy train students in dive theory and practical skills such as buoyancy control. During September Intensive Week, students spend a great deal of time studying in the classroom and practicing in the pool; the week culminates in a trip to Homestead Crater in Utah, a geothermal crater with a depth of 65 feet, for their final diving exams. As regular classes resume at Polaris, these newly certified divers attend weekly after-school meetings focused on research and fundraising. This is where the power of the NOAA Planet Stewards Education Project really takes hold.

### Curriculum and Student-Led Presentations

The Colorado Coralition was accepted as a NOAA Planet Stewards funded project during the 2018-2019 school year. Participation in this federally funded program created an opportunity to bolster this third iteration of the Coralition with diverse scientific frameworks and resources. Throughout much of the school year, Dr. Strand and his students met weekly for after-school workshops that focused on an integrated approach to scientific inquiry and literacy. Many of these workshops centered on coral biology, global and regional stressors to coral reefs, rates of decline, and evaluating coral restoration solutions. Educators interested in Next Generation Science Standards (NGSS, 2017) and Cross Cutting learning opportunities that relate to coral decline and restoration practices can look to the following Disciplinary Core Ideas:

- Ecosystems: Interactions, Energy, and Dynamics in Ecosystems (MS-LS2-5, HS-LS2-7)
- Earth and Human Activity (MS-ESS3-2, MS-ESS3-3, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5)



**Figure 4.** Quinn, a 7th grader, cleans algae from a coral tree in the Coral Restoration Foundation offshore nursery.

Photo credit: Matt Strand

Coral studies provide unique opportunities to integrate an NGSS-based curriculum with Ocean Literacy Essential Principles and Fundamental Concepts (National Marine Educators Association, 2020). These include Principles 3, 5, 6 and 7. Combining NGSS with the Ocean Literacy Framework provides a robust curricular springboard that inspires students to take decisive action.

The Planet Stewards program also bolstered the scientific depth of the Coralition by providing increased access to NOAA resources, data, and experts. Dr. Strand organized live video conferences with experts such as Dr. Mark Eakin, coordinator of NOAA's Coral Reef Watch, as well an in-person visit by Zack Rago, who was featured in the Emmy-awarded 2017 Netflix documentary *Chasing Coral*. After these interviews, students chose from subtopics related to coral science and restoration engineering and prepared presentations that took place

during the February Intensive Week. As part of the OtterCares Closed2Open (<https://ottercares.org/closed2open>) campaign, volunteer employees from Fort Collins-based OtterBox visited Dr. Strand's classroom to give tips and feedback to students as they rehearsed their presentations. This experience helped Coralition students lead an immersive event in the 360° OtterBox Digital Dome Theater at the Fort Collins Museum of Discovery. In front of a large audience that included Dr. Joanie Kleyvas of the National Center for Atmospheric Research and US Congressman Joe Neguse, Coralition students provided in-depth details on topics such as the biology of coral, the ecology of coral reefs, the impact of climate change, regional stressors in the Florida Reef Tract, restoration techniques, and ways to reduce the collective carbon footprint on Colorado's Front Range. Clearly, the backing of the NOAA Planet Stewards program had a definitive impact on students' depth of knowledge, confidence, and commitment to environmental stewardship.

### Trip Preparation

While researching and preparing presentations for their topics, students also focused on fundraising to support their trip to Florida. Some students started crowdfunding campaigns, while others started small businesses. Group fundraising events such as T-shirt sales and ocean-themed school dances gave students yet another opportunity to work as a team. These students also had additional opportunities to hone their scuba diving skills throughout the year (video of the Christmas tree dive challenge – <http://bit.ly/coralitiontraining>). These yearlong efforts, combined with the Planet Stewards program, helped make dreams of diving in Florida a reality.

## Planet Stewards Project and Results

Upon arriving in Key Largo, Coralition students deepened their scientific knowledge at the CRF Exploration Center, a hub for promoting engagement in coral science and restoration. The CRF website (<https://www.coralrestoration.org/>) also provides a vast array of information about coral restoration methodology, free standards-based classroom activities, national STEM competitions and challenges, and the OK Coral app-based citizen science program. Coralition students spent half-days engaged in customized lessons and hands-on training with marine biologists before heading out for the CRF dive program.

**Table1. Colorado Coralition Monitoring Data: Carysfort Reef (May 31st, 2019)**

| Genotype | Cluster | # Alive | #Dead | Fused/<br>Not Fused |
|----------|---------|---------|-------|---------------------|
| U75      | 112     | 10      | 0     | NF                  |
| U75      | 114     | 11      | 0     | NF                  |
| U63      | 145     | 10      | 0     | NF                  |
| M20      | 44      | 9       | 0     | NF                  |
| U44      | 165     | 11      | 0     | NF                  |
| K2       | 428     | 11      | 0     | NF                  |
| B10      | 97      | 10      | 0     | NF                  |
| B8       | 90      | 10      | 0     | F                   |
| U41      | 185     | 10      | 0     | F                   |
| J41      | 183     | 7       | 0     | NF                  |
| MS       | 38      | 11      | 0     | NF                  |
| MS       | 385     | 10      | 0     | F                   |
| UII      | 185     | 10      | 0     | NF                  |
| NA       | NA      | 1       | 0     | NF                  |
| NA       | NA      | 0       | 1     | F                   |
| B8       | 91      | 9       | 0     | F                   |
| J41      | 184     | 9       | 0     | F                   |
| UNK      | UNK     | 3       | 2     | F                   |
| NA       | NA      | 0       | 4     | F                   |
| NA       | NA      | 11      | 0     | F                   |
| NA       | NA      | 13      | 0     | F                   |
| KI       | C671    | 11      | 0     | F                   |
| NA       | NA      | 7       | 5     | F                   |
| NA       | NA      | 4       | 9     | F                   |
| C91      | B8      | 3       | 0     | F                   |
| NA       | NA      | 6       | 0     | F                   |
| NA       | NA      | 2       | 0     | NF                  |
| NA       | NA      | 3       | 0     | NF                  |
| NA       | NA      | 4       | 0     | NF                  |
| NA       | NA      | 1       | 0     | F                   |
| NA       | NA      | 5       | 2     | F                   |
| NA       | NA      | 8       | 2     | NF                  |
| NA       | NA      | 2       | 0     | NF                  |
| NA       | NA      | 2       | 0     | NF                  |
| B10      | 96      | 8       | 0     | F                   |
| U35      | 129     | 11      | 1     | NF                  |
| UI00     | 107     | 10      | 0     | NF                  |
| U30      | 50      | 11      | 0     | NF                  |
| U106     | 42      | 9       | 0     | NF                  |
| B8       | 112     | 10      | 0     | NF                  |
| U44      | 164     | 10      | 0     | NF                  |
| U44      | 165     | 9       | 0     | NF                  |
| UIS      | 132     | 11      | 0     | NF                  |
| KW16     | 35      | 10      | 0     | NF                  |
| KW16     | 36      | 11      | 1     | NF                  |
| U17      | 12      | 9       | 0     | NF                  |
| U41      | 206     | 9       | 0     | NF                  |
| NA       | NA      | 3       | 5     | NF                  |
| UI00     | 107     | 10      | 0     | NF                  |
| U39      | 50      | 10      | 0     | NF                  |
| U106     | 42      | 9       | 0     | NF                  |

### Results

**Total Recorded Coral Fragments: 435**

403 Corals Alive

32 Corals Dead

*92.64% Survivorship*

**Total Number of Clusters: 51**

33 Clusters with No Fusion Observed

18 Clusters with Fusion Observed

*64.7% Observed Fusion*

Coralition students descend in small teams, led by marine biologists and accompanied by dive masters, to tackle a variety of tasks on the ocean floor, such as coral nursery maintenance and coral monitoring. The most powerful learning takes place through these dives.

### Underwater Gardening

In the coral nursery, CRF’s innovative “coral trees” –

large PVC structures with monofilament for hanging coral fragments – allow coral farming to take place. However, much like weeds take to a garden, algae can take over a coral tree. To keep young corals healthy, the trees and monofilament must be regularly cleaned. Coralition students learned how to scrub these underwater structures free from algae and other biofoul. They also learned how to tag fragments with identifying information and “harvest” them from the trees for out-planting. Students did several dives in the nursery, working hard to clean eight coral trees to ensure hundreds of corals would grow healthy and strong.

### Citizen Science Data Collection

Coralition students also used their citizen science training to collect data on outplants at Carysfort Reef. Working in pairs, students spread out across the reef and studied coral clusters carefully for signs of disease, mortality, and fusing (coral fragments growing together to form more structural complexity). Students carefully collected



**Figure 5.** Jaya and a recently out-planted elkhorn cluster on Carysfort Reef.

Photo credit: Matt Strand



identifying information from each coral tag to produce reliable data. During their citizen science project, Coralition students assessed the health of 435 individual coral fragments, observing 92.64% survivorship on Carysfort Reef. These student dive teams also observed that 33 of 51 (62.7%) of observed coral clusters demonstrated fusion.

These student-generated data were compiled by CRF and reported to the NOAA Florida Keys National Marine Sanctuary, the NOAA Restoration Center, and the Florida Fish and Wildlife Conservation Commission. Additionally, the data is available to researchers who utilize CRF facilities, corals, or data to promote coral reef research. Coral monitoring plays a critical role in determining the resilience of specific genotypes and the success of coral propagation. Therefore, Coralition students participated in one of the most essential tasks in bringing endangered reefs back from the brink.

## Conclusion

To date, over 50 middle and high school students have participated in the Colorado Coralition. Several have gone on to major in marine biology at the postsecondary level. It is this type of experience that impacts participants in lasting ways. As Noah, a 7th grader in the Coralition shared on the last night of the trip, “The Coralition is something I will never forget, and I will carry the lessons and skills I learned throughout my entire life.” Why are real-world problems such powerful learning experiences? Perhaps it is simple as this: there is no answer in the back of the book. Somewhere along the fault lines of the unknown lies the opportunity for meaningful learning for students and their teachers, a place where concern for the state of the natural world inspires a desire for knowledge, innovation, and shared purpose. When students and teachers have the courage to face humanity’s most pressing dilemmas, a deep sense of hope fuses with the brilliant light of possibility.

## About the Authors

**Dr. Matt Strand** teaches 7th and 8th grade English and serves as the middle school team leader at Polaris Expeditionary Learning School in Fort Collins, Colorado. He has also served as a national coach for EL Education’s Better World Project. He earned his M.Ed. in 2001 in Educational Research and Collaboration from Texas Christian University with an emphasis on experiential models of school reform. He went on to earn his Ph.D. in 2013 in Education and Human Resource Studies from Colorado State University with a focus on authentic professional learning. He has used experiential, project-based, and student-centered assessment models to engage learners for over twenty years. He can be reached at [mstrand@psdschools.org](mailto:mstrand@psdschools.org).

**Derek Hagen** is the Education Program Manager of the Coral Restoration Foundation™, leading the internship and volunteer force. With over 1200 hours of public speaking engagements and over 100 educational activities published, his goal is to inspire others and train others to improve the health of the world’s reefs, using CRF™ work as an example. Previously, he worked as a professor at Oak Ridge Military Academy teaching courses such as Zoology and Oceanography. He can be reached at [derek@coralrestoration.org](mailto:derek@coralrestoration.org).

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