OCS Study
BOEM 2024-007

Student Engineers Advancing Ocean Technology (SEAoTech) Final Report

U.S. Department of the Interior

Bureau of Ocean Energy Management

BOEM Alaska Regional Office, Anchorage, AK

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Student Engineers Advancing Ocean Technology (SEAoTech) Final Report

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ABOUT THE COVER

Photo of students involved in the building of the miniboat from Henry Reiske of the Center for Alaskan Coastal Studies.

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List of Abbreviations and Acronyms

AK................. Alaska

BB .... Blackbeard Biologic

BLE LTER .... Beaufort Lagoon Ecosystems Long Term Ecological Research

BOEM .... Bureau of Ocean Energy Management

BWRI .... Blue World Research Institute

CACS .... Center for Alaskan Coastal Studies

CTD............... Conductivity, temperature, and depth

EP.................. Educational Passages

IDIQ .... Indefinite Delivery, Indefinite Quantity

KOP............... Kaktovik Oceanography Program

NSF .... National Science Foundation

SEAoTech ..... Student Engineers Advancing Ocean Technology

STEAM .... Science, technology, engineering, art, and math

1 Executive Summary

The Bureau of Ocean Energy Management (BOEM) supports and encourages secondary school education programs that teach students about marine science and the importance of marine ecosystems. During 2022 and 2023, the BOEM Alaska Regional Office, Blue World Research Institute, Center for Alaskan Coastal Studies, Blackbeard Biologic, and Educational Passages ran the Student Engineers Advancing Ocean Technology (SEAoTech) project that teaches students how to build and deploy low-cost miniboat and OpenCTD oceanographic instruments. During the project, student groups from select Alaska schools built, deployed, and collected data with 3 sensor-equipped miniboats and 3 OpenCTD units. The project taught students how to analyze their data, compare them with data collected by local agencies, and use the results to answer scientific questions relevant to the local community and ecosystem. Throughout the project, we collected feedback from the involved students and teachers. We also observed and noted where the project methods were effective and where they could be improved. We used the feedback and observations to update the curriculum and materials for future courses.

2 Introduction

The *Student Engineers Advancing Ocean Technology (SEAoTech)* project successfully provided an opportunity to build and enhance partnerships between the Bureau of Ocean Energy Management (BOEM) and local entities, research programs, and educational organizations in Alaska (AK) through the OpenCTD and Educational Passages Miniboat Programs. These two programs both guide the building of low-cost oceanographic instruments. The OpenCTD is an oceanographic instrument that measures conductivity, temperature, and depth (CTD) and can be deployed by hand to a depth of 140m. This open-source version of a commercial CTD forms the backbone of any marine scientific research program and can be built, operated, maintained, and calibrated by the end user. The Miniboat is a 1.5m long uncrewed sailboat that captures GPS location, wind and current information, air and water temperature, pitch, and images from a camera as the boat sails. The SEAoTech project provided a unique hands-on learning opportunity for students in Chapman K-8 and Homer Flex Alternative (High) School near Homer, Alaska. The result was five-fold: 1. The students created new OpenCTD and Miniboat oceanographic research tools using the supplies and guidance provided by project partners and collaborators. 2. Project partners learned how their programs were implemented by closely participating in and receiving feedback from the students and teachers involved. This allowed for revisions and upgrades of resources, such as building manuals and planning processes (including shopping lists and materials needed). 3. Implementation of these programs helped the students develop important science, technology, engineering, art, and math (STEAM) related skills, confidence, and knowledge that they can apply in a marine science context. 4. The project highlighted local and cultural connections to the ocean and engaged the community throughout. 5. Oceanographic data gathered by the projects' miniboats has been made openly accessible via the Educational Passages website along with a map highlighting the key data points (https://educationalpassages.org/seaotech/).

3 Revised Geographic Scope

The study's geographic scope initially included both Homer, AK and Kaktovik, AK. Engagement with students and teachers in Kaktovik, AK was interrupted by the COVID-19 pandemic and changes in city government and school administration's openness to outside visitors and projects. Given these dynamic situations, we decided to focus this first round of the SEAoTech project in greater Homer where the Center for Alaskan Coastal Studies has greater familiarity and more robust relationships with the schools. This was a successful strategy, and we quickly learned that long-term, in-person instruction and project support at the schools from CACS staff were critical to the project's success. Implementing a similar project in Kaktovik would likely require a very committed teacher and/or a dedicated intern, either of whom would need significant in-person training from Educational Passages/OpenCTD.

4 Overview of Project Goals

Goals for the communities involved from Homer included:

1. Engage upper elementary and/or middle school students in a classroom-based project to build and deploy a miniboat.
2. Customize the existing miniboat curriculum to integrate experiential learning in Homer.
3. Involve middle school and/or high school students in classroom-based workshops to build an OpenCTD.
4. Customize the existing OpenCTD workshop for place-based learning in Homer.
5. Conclude with a field trip for each project to deploy the miniboat, utilize the OpenCTD, and investigate various topics related to ocean science through plankton tows, seabird observations, and gathering water quality data.

4.1 Attainment of Project Goals

Goal 1. The 6th-8th grade students at Chapman School in Anchor Point, AK were engaged in two cycles of a classroom-based project to build and deploy a miniboat. The students worked in teams and were guided by workbooks from Educational Passages, allowing them to customize their boats and work together throughout the build. Participants also met with and communicated with Cassie from Educational Passages via Zoom sessions throughout the project. These sessions gave the students a global perspective on the project by updating them about other miniboat voyages around the world. The first build was during the spring of 2022 and the second build was in the fall of 2023. Because of this, the 8th-grade students of fall 2023, who participated in the project as 6th graders in spring 2022, guided and mentored younger students new to the project. Classroom sessions happened 1-2 times per week; each class lasted 1-1.5 hours. Students were divided into 2 (2022) and 3 (2023) separate classes based on their grade.

Goal 2. The miniboat curriculum was customized and enhanced to include several place-based learning activities that integrated the boat-building tasks with learning opportunities for topics such as marine debris, water quality, etc. CACS staff implemented these activities in the classroom and continued to support the classroom teacher throughout the project. Local resources were incorporated into the lessons, including water temperature, salinity, and current data gathered by the Kachemak Bay National Estuarine Research Reserve and local NOAA facilities. Incorporating these data allowed the project to compare and contrast them with the student-collected data. It also led to discussions about the importance of agency data collection efforts and how community-collected data could fill data, add insights, or allow local data possession. In 2022, miniboat participants also took part in the Recycle Regatta, an annual event that encourages environmental stewardship, hosted by Educational Passages, the New England Science & Sailing (NESS), and the North American Marine Environment Protection Association (NAMEPA). The competition allowed students to design and build boats out of recyclable materials. They raced their boats and submitted speeds and designs to the national competition. Chapman won two entries for "Most Seaworthy". In the fall of 2023, students began testing the salinity and observing visual characteristics (color, turbidity, etc) of water gathered from various locations along the Anchor River and Cook Inlet. This information, combined with temperature data, was used to hypothesize from where the water was collected. These examples of successfully paired activities will now be recommended in the miniboat curriculum for future participants.

Goal 3. Three different classes at two different schools built and deployed an OpenCTD. High school students from Homer Flex School built an OpenCTD in the spring of 2022. These classes took place 1-3 times per week, depending on the build stage, school schedules, and CACS staff availability. While Andrew Thaler did provide some guidance to the entire class via Zoom, this format was sometimes challenging for this group of students while they engaged with the build. We learned the importance of having in-person support for the teacher and students during the construction. Andrew Thaler's input was more effective when he was on a laptop with a smaller subset of students and they could engage with them at the beginning or end of various build stages to check their understanding and ask him clarifying questions. His guidance via Zoom, phone, and e-mail was critically important to the CACS educators between sessions as they double-checked the student work and made sure they understood how to guide students through the next step of the build. Two classes of 7th-grade students from Chapman K-8 School built an OpenCTD in spring 2022 and fall 2023. These classes also took place 1-3 times per week and followed a similar methodology for conveying Andrew Thaler's instructions and helpful tips to the students.

Goal 4. At Homer Flex School, the OpenCTD build included a wide range of place-based activities. The project commenced with testing water samples from various locations around Homer to investigate what salinity and temperature can tell us about water. Students also used microscopes to look at phytoplankton and zooplankton samples from Kachemak Bay. Researchers from the Kachemak Bay National Estuarine Research Reserve discussed their own CTD and remote sensor projects with the students and helped the students visualize and interpret the data from the OpenCTD. Finally, students created art to decorate the OpenCTD and as part of communicating the larger project (Figure 1). This art was displayed at a First Friday art exhibit open to the community. Overall, the teacher helped us to create an effective, differentiated teaching approach where the students could engage in various aspects of the OpenCTD building, practice soldering, create art to go on the outside of the CTD, develop media, plan the field trip, and engage in hands-on science activities. This sort of informal specialization amongst the students allowed them to build confidence and ownership of the project, and the teacher helped us foster peer leadership moments across the various groups and skill sets. Future projects should try to embrace this highly effective and flexible educational approach.

Figure 1. Students from Homer Flex show off a decorated OpenCTD
Photo by Beatrix Strobel/Homer News

At Chapman School, the OpenCTD builds and miniboat builds included activities focused on developing research questions that could be addressed through data collected by the OpenCTD, miniboat, and/or plankton tows conducted during the OpenCTD deployment.

Goal 5. All three participating groups (Homer Flex spring 2022, Chapman 6th-8th spring 2022, and Chapman 6th-8th fall 2023) participated in oceanography field trips. The Homer Flex field trip included deploying the OpenCTD, collecting plankton and microscope lab, and deploying Niskin bottles for a comparative, manual sampling of temperature and salinity. Students then traveled to the NOAA/University of Alaska Fairbanks Kasitsna Bay Lab. Their time at the Lab included a brief tour followed by intertidal exploration. One of the guiding questions for the investigation by Homer Flex students focused on marine and intertidal ecosystem conditions and evidence for clam population recovery in the Kasitsna/Jakolof Bay area. This question was of interest to the nearby community of Seldovia, and the students were very interested in looking for live clams and empty clam shells on the beach (of which they found a significant number) as well as investigating plankton abundance as an indicator of food availability for clams. In a particularly powerful moment during this trip, while we were dropping the CTD and towing for plankton to look at the population compared to salinity and temperature, we spotted humpback whales around the boat. On the boat's radar, we identified the school of bait fish or large plankton the whales were eating. Although this fish school was out of the reach of our plankton tows, it was a wonderful demonstration of interacting ecosystem factors and the usefulness of tools for studying the water column.

In 2022 and 2023, Chapman field trips included launching a miniboat and deploying an OpenCTD. During these field trips, students gathered plankton samples and water quality data from at least 3 locations in the bay to compare the conditions and life from samples taken by the harbor, near the mouth of a glacial river, and a location with less freshwater input. The students used these samples to inform experiments, create science project displays, and perform a plankton species survey. The data from the miniboat were made available for the 2023 students to provide context and additional resources for their studies.

5 Additional Evaluation Information

Students at Chapman completed daily project reflections during the building of the first miniboat. Educational Passages monitored these reflections that now serve as a log of effort. A form was completed each week by members of all teams. Questions included:

- How did the project go today?
- What was something successful that happened today?
- What was something that was a challenge today?
- Was the challenge resolved today? If so, how?
- What is the next step?

The responses to the daily project reflections were highly variable. They show that each team's experience differed from the others and varied from week to week. Even with this variability, we identified some interesting snippets about communication and teamwork in the responses. For example, one team responded to the questions for week 3 as follows (different colors indicate a different student responding):

How did the project go today?
"Okay but slightly bumpy."
"Good."

What was something successful that happened today?
"We finished all our tasks."
"We brainstormed a cargo list."

What was something that was a challenge today?
"Picking out things to put in the cargo."
"Getting everybody to agree."

Was the challenge resolved today? If so, how?
"We figured it out by listening to each other."
"The instructors helped us with our problems."

Student reflections such as these highlight the important teamwork and communication skills that the students practiced throughout the project, and the teacher and CACS educators' role in providing as-needed, direct support to the students. These themes also emerged in the post-project teacher interview.

We conducted a post-project interview with the Chapman School science teacher following the spring 2022 session. The science teacher highlighted some especially positive core project aspects. First, by working in small teams the students were able to build social connections with each other, their teacher, and the CACS educator. These connections were amplified by the long-term nature of the project, and the allowance of one-on-one connection and support for students, even as they worked in teams. The teacher also mentioned that the students responded to the great energy brought by the CACS educator. In addition, the curriculum's flexibility allowed students with diverse educational needs and challenges to meaningfully participate in the project. Finally, the teacher noted that having all the materials in the "kit format" made this project much more feasible because the school may not have the funding or personnel to procure the materials on their own.

He went on to say that he has worked in both private and public schools and strives to bring projects like this into his classroom, but "this is the first time [he] had that magic happen."

The teacher also suggested improvements. These included:

1. Planning for smaller groups.
2. Making more connections to the bigger picture of science, maritime industries, and the importance of a healthy ocean.
3. Planning for more flexible, easy-to-lead activities for the in-between times during the build or when some groups were ahead of others.

We did not use the feedback form during the second miniboat build due to a shorter timeframe and we have not conducted any further post-project interviews. However, we strongly recommend building in monitoring at all stages in the future, including pre and post assessment and evaluation.

Less formal evaluation took place with the Homer Flex class for a variety of reasons, but a participant in that class recently expressed to us that they would like to do a similar project again and would enroll in a class with such a project, even though they do not need any further science credits. Homer Flex students submitted an article to the Homer News that included their perceptions of the project. This article can be accessed at: Homer Flex students do research in Kachemak Bay | Homer News

6 Production and Deployment of Miniboats and OpenCTDs

Three miniboat kits were assembled at the Educational Passages main office in New Hampshire. Two were shipped to staff at CACS in Alaska, one in 2022 and one in 2023. These two kits were turned into miniboats by students at Chapman School.

The students named miniboat #1 *APAK* (which stands for Anchor Point AlasKa) and it was launched twice in Kachemak Bay during the spring of 2022. The first launch was by the students during the field trip which was explained earlier. The miniboat landed soon after in Peterson Bay. Captain Garth recovered and launched APAK for a second voyage in Kachemak Bay and after another short trip, APAK landed in Halibut Cove Mako's Water Taxi picked it up. *R/V Tiglax* of the Alaska Maritime National Wildlife Refuge launched APAK a third time in the summer of 2022. After 10 days at sea, APAK landed on Amlia Island. It remains on the island and outreach continues to find someone who can recover the miniboat. APAK successfully collected sensor data and images from the on-deck camera during all three voyages. The voyage map and information about APAK's deployments are in Figure 2. The voyage map and APAK's full story can be seen at https://educationalpassages.org/boats/apak/.

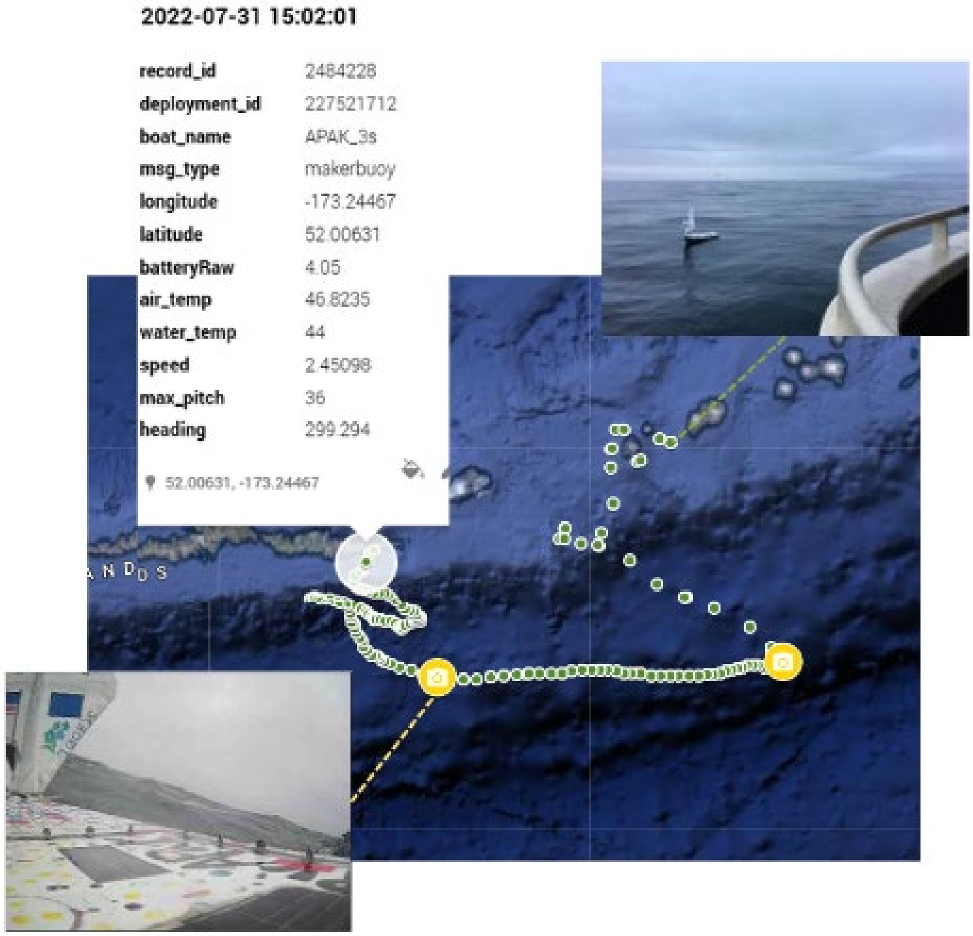

Figure 2. Information about APAK's miniboat deployments.
Central image: A map of Aleutian Islands and locations of data collected by the *APAK* miniboat. Top right image: A picture of boat at sea after launch from R/V *Tiglax*. Bottom left image: An example of an image collected by APAK on July 22, 2022. Top left image: An example of APAk's sensor data output.

The students named miniboat #2 *907 SEAS*. *907 SEAS* completed its Kachemak Bay voyage in October 2023 after only a few hours. It washed up in Mud Bay and was quickly recovered. *907 SEAS* successfully collected sensor data and images from the on-deck camera during the voyage. The boat required some paint touch-ups, as well as approval from the Coast Guard, before a full launch could take place. *907 SEAS* is planned to be launched in early 2024 by a charter fishing boat in Cook Inlet. The voyage map (current and any future launches) along with the full story can be seen at https://educationalpassages.org/boats/907seas/.

Miniboat #3 remained with EP staff at the main office and was used as a visual tool to support the remote build in Alaska, which provided easier implementation for project participants. We took new pictures and videos of miniboat #3 while it was being assembled during the project. We incorporated the new media, along with feedback from EP staff and participants in Alaska, into existing project resources, such as the build manual. We also revised the material set based on the 2023 build which will help all future participants in the program. Miniboat #3 is not deployable and will remain with Educational Passages as an instructional tool.

OpenCTD #1, built by students at Homer Flex School, was deployed in spring 2022. One out of the two deployments collected data that seemed accurate (Figure 3). Science topics rotate at Flex, and at the end of the marine science course, this CTD was loaned back to Coastal Studies. This CTD is used as a model and to demonstrate the CTD with other classes either before their build or independently.

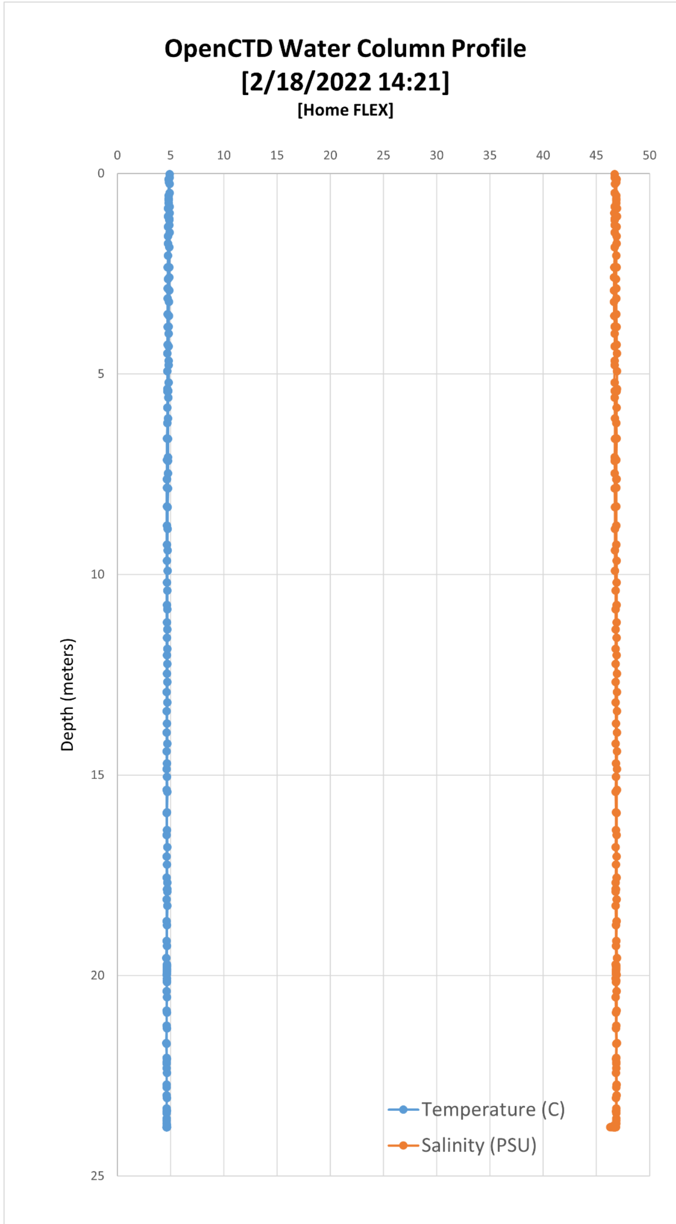

Figure 3. A water Column profile produced by Homer Flex OpenCTD.
Note that salinity calibration is likely high. Updated calibration protocols were developed as part of this program.

OpenCTD #2, built by students at Chapman School, was deployed in spring 2022. It sustained flood damage upon deployment.

OpenCTD #3, built by students at Chapman School, was deployed in the fall of 2023 in the harbor before and during the launch of a miniboat. OpenCTD #3 recorded data on two dives in the Bay at the site of the miniboat launch and in the harbor. On the first dive, the CTD reached the floor of the harbor and captured a profile. During the second dive, the CTD reached a depth of around 40 feet. During previous CTD dives, the strong current of Kachemak Bay dragged the CTD sideways a significant amount even with weights attached. For this dive, even more weight was added to help the CTD reach greater depths. This data was evaluated in the classroom and compared to the surface temperature readings of the miniboat during launch. This CTD was borrowed for a demonstration at the Alaska Out of School Time Conference and will be returned to Chapman School which is interested in using it further to test the water at Anchor Point Beach and around the mouth of Anchor River.

7 Participant Numbers

Community	School	Grade/Class Name	Year	Project	# of students	# of teachers
Anchor Point	Chapman School	6th, 7th (5th) grade science	Spring 2022	OpenCTD & Miniboat	81	3 (1 teacher, 2 aids)
Homer	Homer Flex School	Biology (high school)	Spring 2022	OpenCTD	12	2
Anchor Point	Chapman School	6th, 7th, 8th grade science	Fall 2023	OpenCTD & Miniboat	54	1

Table 1. A breakdown of project participants by school and year

It should be noted that 15 of the 18 8th-grade students (8th-grade students made up 18 of the 54 students involved) at Anchor Point were involved in both miniboat builds, one in the Spring semester of 2022, and the second in the Fall semester of 2023. The students involved in both miniboat builds got a unique opportunity to assist and mentor new students during the second build session, as well as provide more detailed feedback on the builds due to their involvement in both build sessions.

8 Project Outreach

8.1 Conferences, presentations, papers, etc.

The SEAoTech project was presented in a poster session (Figure 4) at the 2023 Alaska Marine Science Symposium, January 2023: *Expanding ocean observations with open-source tools and experiential learning* 2023 AMSS Abstract Book (flippingbook.com).

Figure 4. Image of the poster presented at the 2023 Alaska Marine Science Symposium

The *Enabling tools for citizen science in ocean data collection* panel, sponsored by the ETT Group and The Ocean Race in May 2023, mentioned the SEAoTech project. Both Educational Passages and Blackbeard Biologic mentioned the SEAoTech project in their panel presentations to attendees in person and online. Figure 5 shows a slide from the Educational Passage's presentation.

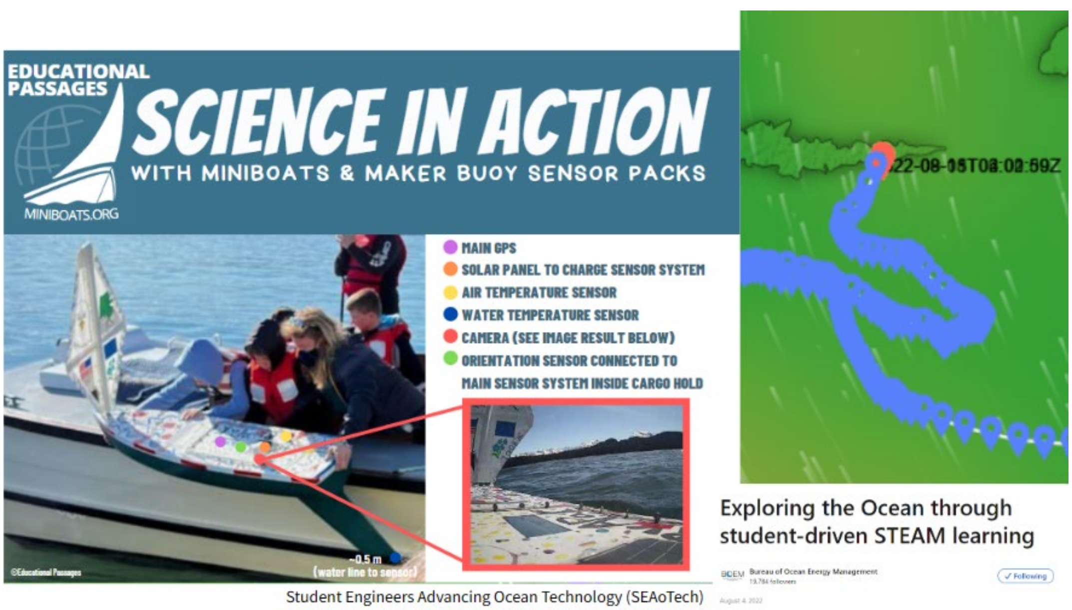

Figure 5. A slide from Educational Passage's presentation at the Enabling tools for citizen science in ocean data collection panel

At the Alaska Out of School Time Conference on November 17, 2023, the overall goals and process of the OpenCTD and miniboat projects was presented to an audience of after-school educators representing organizations from around the state. The session also included hands-on activities either directly from builds and deployments or those made to simulate the activities that students took part in during the hour-and-a-half presentation. During the session, activities educators participated in:

- Tracking miniboats
- Deploying CTDs in samples of water with various temperatures and salinities
- Designing and attaching sails
- Choosing a deployment location for their home community
- Taking the Educational Passages pre/ post knowledge test
- Filling out a modified student daily evaluation

8.2 Media

- Project updates were shared through multiple podcast episodes on the Educational Passages Podcast during the project period.
- Homer Flex students do research in Kachemak Bay | Homer News (June 2022)
- Chapman School's student-made mini-boat journeys to Bering Sea | Homer News (July 2022)
- Exploring the Ocean through student-driven STEAM learning | LinkedIn (August 2022)
- Two OpenCTDs programs that reshaped how I think about hardware development | Hackaday.io (October 2022)

8.3 Social Media Outreach

- Educational Passages posted a picture of APAK (the first miniboat in the project) at sea as their profile picture in May 2022.
- Facebook post May 2022 - CACS
- Facebook post August 2022 - BOEM
- Facebook post October 2023 - CACS
- Updates were also posted on Twitter

8.4 Peer-reviewed Publications

The SEAOTECH OpenCTD project is cited as a case study in Thaler et al 2024:

Thaler, A., S.K. Sturdivant, R.Y. Neches, and J.J. Levenson. 2024. The OpenCTD: A low-cost, open-source CTD for collecting baseline oceanographic data in coastal waters. *Oceanography*, https://doi.org/10.5670/oceanog.2024.602.

9 Lessons Learned

For the first build, we did not deploy any units during the school year but waited to deploy until the second school year. This approach was valuable. It allowed the students more time to be involved in the launch, recovery, and relaunch process, which we hope will create more buy-in and interest. For future projects, we believe additional monitoring and evaluation of this period would be useful. During this project, most support focused on the hands-on building opportunity for students. We learned that additional time is needed to incorporate student-guided research and data analysis support. We recommend dedicating more support and time to help students analyze the miniboat and OpenCTD data.

The remote technicians provided as much support as possible, including virtually training educators. However, we prefer in-person support at the start of the project. This would also allow the technicians to highlight the physical needs of the project, which challenging to do virtually.

We had originally planned to implement the first miniboat build with the CACS after-school program. We changed our plan after the Chapman School science teacher expressed great enthusiasm to implement the miniboat and OpenCTD projects in his classes. This shift allowed more students to participate in the project and was positively received by the school. Since Chapman School typically has financial barriers for projects and field trips like Miniboat and OpenCTD, we feel this school especially benefited from the project.

10 Extended Outcomes

Another project outcome was collaboration beyond the project scope. For example, Cassie and Andrew discussed synergies with the sensor systems in their programs. During the Ocean Race panel presentation mentioned in the Project Outreach section above, Cassie connected Andrew with the engineer at MakerBuoy, who designed and made the sensor packages for the miniboats. Collaborating and sharing recommendations has continued and will help to advance all the systems within the SEAoTech project.

11 Core Partners

The core partners for this study include Blue World Research Institute, the Center for Alaskan Coastal Studies, Blackbeard Biologic, and Educational Passages. A summary of each organization is included below:

11.1 Blue World Research Institute

Blue World Research Institute (BWRI) is a technology-focused research organization located in Cocoa, FL. BWRI is a non-profit organization with a central mission to use technology to gain a better understanding and awareness of complex issues that affect marine life and environments to develop management and mitigation plans for more effective conservation of animals and their habitats. BWRI was awarded the Indefinite Delivery, Indefinite Quantity (IDIQ) #140M0121D0004 from BOEM for Telemetry, Communication, and Engineering Services, and the Student Engineers Advancing Ocean Technology (SEAoTech) Community Engagement Plan is an issued Task Order under the IDIQ.

11.2 Center for Alaskan Coastal Studies

The Center for Alaskan Coastal Studies (CACS) is a non-profit organization located in Kachemak Bay, AK. CACS is well-positioned to develop and deliver educational programs, including the SEAoTech Community Engagement Plan. The organization was founded in 1982 by residents from Homer and Kachemak Bay and has maintained its identity as a community-based organization from the beginning. CACS focuses on experiential learning for students of all ages and provides nature-based programming, guided tours, and school programs. Each spring and fall, CACS hosts overnight field trips at their Peterson Bay Field Station and Kasitsna Bay Lab for 30+ students in grades K-12. Students learn about coastal science, stewardship, and human connections to Kachemak Bay through activities including tidepooling, plankton labs, forest ecology hikes, ethnobotany, scientific sketching, hands-on observation of cultural objects and tools, and water quality testing. CACS has developed a robust curriculum with a focus on place-based and culturally-responsive learning. CACS's work also includes the Kachemak Bay CoastWatch program where citizen scientists adopt a section of shoreline to survey and collect data and marine debris. Each year, hundreds of community volunteers and K-12 students participate in their CoastWatch program.

CACS is also connected to Beaufort Lagoon Ecosystems Long Term Ecological Research (BLE LTER). BLE LTER was established in 2017 with funding from the National Science Foundation (NSF) and is based out of Utqiaġvik (formerly Barrow), Deadhorse, and Kaktovik in the Beaufort region. The Principal Investigator for BLE LTER, Ken Dunton, PhD, has conducted research around Kaktovik for decades. Ken also created the Kaktovik Oceanography Program (KOP), an annual summer program that offers hands-on science education for local K-12 students, in 2008. KOP bridged the end of summer break to the beginning of the school year and maintained connections with students throughout the school year. Unfortunately, the 2020 and 2021 KOP sessions were canceled due to the COVID-19 pandemic.

Katie Gavenus, Program Director for CACS, serves as the education coordinator for BLE LTER and has worked remotely with teachers at Harold Kaveolook School and BLE LTER graduate students to design and deliver hands-on, place-based, locally-relevant virtual learning opportunities on topics ranging from intertidal invertebrates to microbes and DNA extraction. The long tradition of collaboration between BLE LTER (and Dr. Ken Dunton), the Harold Kaveolook School, the community of Kaktovik, and more recently established relationships between CACS and local teachers will help with planning and implementing this study in Kaktovik.

11.3 Blackbeard Biologic

Blackbeard Biologic (BB) is an environmental consulting firm that develops and implements ocean science, conservation, and educational programming around the world and is the fiscal sponsor for the OpenCTD program. Andrew Thaler, PhD, CEO of BB, is a deep-sea ecologist and conservation technologist whose research revolves around how humans use technology to connect with and alter the ocean. He is focused on understanding the impacts of deep-sea mining on biodiversity and connectivity at hydrothermal vents and across the deep benthos, building anticipatory frameworks to guide emerging ocean technology, and developing low-cost open-source tools. He is the founder of Southern Fried Science, the co-founder of Oceanography for Everyone, and the editor-in-chief of the Deep-sea Mining Observer (https://blackbeardbiologic.com).

Andrew, the lead developer of the OpenCTD, has experience developing technology workshops for execution in remote communities. He designed and implemented an underwater robotics workshop in Kavieng, Papua New Guinea at a remote field station operated by the University of Papua New Guinea where access to electricity, communication, and regular shipping was limited. Using only outdoor classrooms, students built and deployed six observation-class ROVs in Kavieng Lagoon. He implemented a similar workshop in Saipan, Commonwealth of the Northern Mariana Islands, in partnership with a local trade school, in a program designed to provide instructor training and capacity building, as well as a hands-on STEAM experience for high school students. He has run similar programs using both ROVs and the OpenCTD in Terrebonne Parish, LA; Gloucester, VA; and Scituate, MA.

11.4 Educational Passages

Educational Passages (EP) is a non-profit organization whose mission is to inspire ocean stewardship through unique global experiences. EP's miniboat program is designed to support a unique hands-on educational experience and is fully customizable and interdisciplinary. The miniboat-in-a-box kit includes everything participants need to connect through building, launching, and tracking a five-foot-long uncrewed and satellite-equipped sailboat, or "miniboat". By working with a local liaison and/or educator, EP has helped to launch over 200 miniboats that have landed in at least 30 countries. Their model has helped to connect thousands of people and students around the world. EP is well positioned to share its knowledge with communities in AK to ensure study goals are met.

Cassie Stymiest, Executive Director of EP, has extensive experience working with regional organizations to develop and implement programs. She has coordinated all aspects of EP since 2018, which includes supporting educators for all programs. EP's work has partnered with maritime museums interested in connecting students with history, universities focused on engaging students in ocean science research, and K-12 schools interested in experiential learning opportunities. With 10-30 miniboat programs running annually, Cassie has the knowledge and expertise needed to customize and adapt the program for this study.

12 Pictures

Figure 6. Chapman 6th-grade students voting
Students vote on figurehead designs proposed by the 8th grade to represent their school to be 3D printed and attached to the 907 Seas.

Figure 7. Members of the Cargo team during construction
The team members dry-fit the cargo hatch to determine the instrument and solar panel locations.

Figure 8. Chapman 6th grade group photo
A photo of the Chapman 6th grade team with the completed 907 Seas taken shortly before the Kachemak Bay mini launch.

Figure 9. Chapman 6th and 7th grades launch the APAK
The team is launching from a flotilla of water taxis just off of Gull Island in Kachemak Bay before taking water and plankton samples from nearby waters.

Figure 10. Members of another cargo team during construction
Here the cargo team waterproofs and seals the Cargo hatch in preparation for launch.

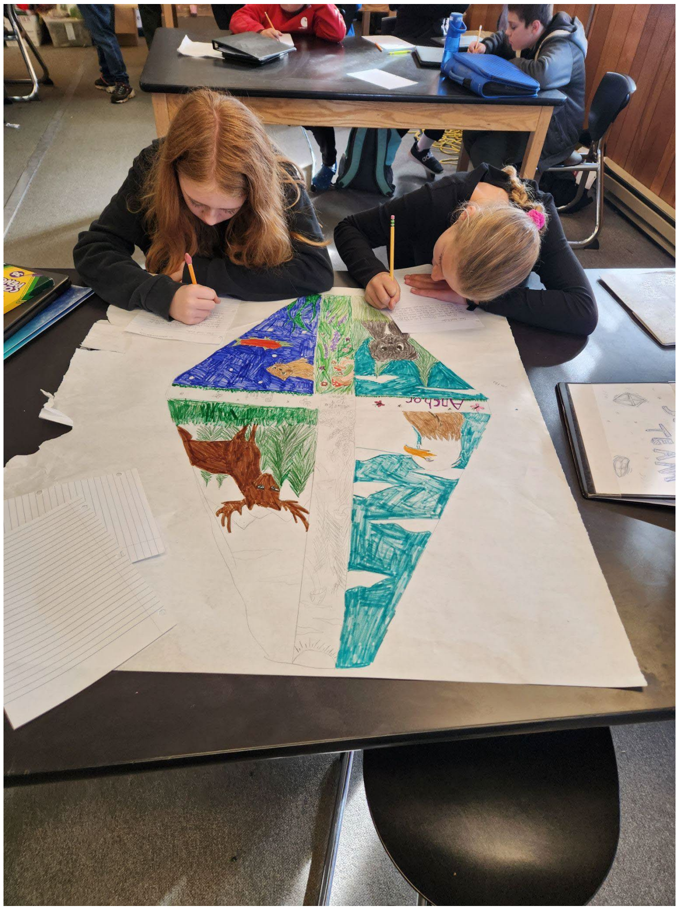

Figure 11. A sail team during construction
Here the sail team finishes coloring in their sail design presented to the class. This design was accepted without changes and became the exact sail design.

Figure 12. Image from a camera installed on a miniboat deck
The camera was connected to a MakerBuoy sensor on the boat and the image was retrieved via satellite.

Figure 13. The APAK on the water after a launch
Here the APAL drifts up the bay after its release, bound for Glacier spit, pushed by currents and winds off of Gull Island.

DOI protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

U.S. Department of the Interior (DOI)

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Bureau of Ocean Energy Management (BOEM)

BOEM Environmental Studies Program

The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).