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**Unit 5**

**OCEAN TECH**

Teacher Guide

Motion and stability; Defining and delimiting an engineering problem; Developing and optimizing a design solution

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Explore Chapter: 5 - Life in the Deep

Time Required: 4 lessons over 14 50-minute sessions

Standards based on grade: 5

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**Background for the Teacher**

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Figure 1 Engineering Design Process flow chart by The Works Museum

In Ocean Tech, corresponding to *Explore the Salish Sea: A Nature Guide for Kids* Chapter 5, Life in the Deep: The Subtidal World, your students will discover that they, like humans since ancient times, are natural engineers. With support from local engineers, the right tools, materials, and safety guidance, they will turn your classroom into an ocean technology design and test site in this unit. They will discover principles of forces and motion out of necessity as they design, build, test, redesign, rebuild, and test again a prototype, then final product, remotely operated vehicle (ROV), with which they can solve their problem: how to complete a research mission in the subtidal world without getting wet.

Engineering is the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people, according to the Massachusetts Institute of Technology. It is an iterative process, meaning that there is a cyclical, or rather spiral, process, beginning with a design that is drawn, then built into a prototype, tested, adjusted, and re-tested until useful technology is attained. Engineering goes beyond science and mathematics. Engineering applies to problem-solving in human health, physical assistance, and basic and culturally appropriate goods, and supplies for hygiene and dignity in humanitarian crises. It is a process that inherently supports teamwork and multidisciplinary collaboration.

It is especially important to allow students to experience the engineering design process as the engineers driving the process, so make sure to

**Sources**

The Works Museum, 2019. The Engineering Design Process. Accessed online at <https://theworks.org/educators-and-groups/elementary-engineering-resources/engineering-design-process/> Last accessed 12/15/2022.

Teach Engineering. Engineering Design Process. Accessed online at <https://www.teachengineering.org/populartopics/designprocess> . Last accessed 12/15/2022.

Cunningham, Christine, 2018. Engineering in Elementary STEM Education: Curriculum Design, Instruction, Learning, and Assessment. Teachers College Press, New York.

**Further Learning and Classroom Resources**

MATE ROV Competition. <https://materovcompetition.org/scoutspecs>

SeaMATE Angelfish ROV kit Assembly Instructions and Education Resources. \*Requires a password provided upon completion of a brief survey on how you will use the resources: <https://docs.google.com/document/d/e/2PACX-1vRuCLqntTX7E9MZstgUVsU3lJk3xhV9N3bK3Y1jHIjdscvxtMM0uwGEaE7mTvRD_8QA654lUcfwW-9l/pub>

Newton

**Unit Overview**

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How can we apply the concepts of forces and motion to engineer an underwater vehicle that can accomplish a research mission?

**Anchoring Phenomenon:** The Nuu-chah-nulth were able to reach deep down to the seafloor to retrieve valuable shells to use for money 2,500 years ago.

**Design Challenge:** How can we engineer a remotely operated vehicle to carry out a subtidal mission?

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| **Lesson 1**  4 sessions  ETS1.A  How can we define and deliminate the problem of subtidal marine debris? | **Lesson 2** 3 sessions  ETS1.B  What are possible solutions for reaching the seafloor in the subtidal zone? | **Lesson 3**  3 sessions  PS2.A and ETS1.C  How can we use balanced and unbalanced forces to optimize our design solution? | **Lesson 4** - 3 days  ESS3.C  How can we use our remotely operated vehicle to gather evidence about impacts of humans on Earth systems near a dock? |
| Session 1  What do we wonder about the Nuu-Chah-Nulth gathering dentalium shells from 60 feet deep?  Session 2  How can you communicate your best idea for how the Nuu-Chah-Nulth gathered dentalium shells 2,500 years ago?  Session 3  What problem do you see on the modern-day seafloor?  Session 4  How can we define the problem so we may begin to consider solutions? | Session 1  How can we communicate an initial idea for technology that can solve the problem of accessing the seafloor near a dock?  Session 2  How will we build our first prototype remotely operated vehicle and test it out? What revisions can we make to improve the structure and function?  Session 3  How will our prototype fare for completing our subtidal mission against other designs? | Session 1  How can we test out the effects of balanced and unbalanced forces on a variety of objects?  Session 2  How can we use balanced forces to attain neutral buoyancy for our ROV?  Session 3  How can we apply unbalanced forces to achieve forward, reverse, up, down, and turning left and right motion with our ROV? | Session 1  How can we design an investigation that uses our ROV to reveal patterns of what is found on the seafloor?  Session 2  Field trip – run the ROV according to the research design and record data.  Session 3  Analyze the ROV mission data and build graphs and/or represent traditional knowledge graphically.  Session 4  Make a claim with evidence and reasoning about your research question. Discuss implications and applications of this new knowledge |
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| **UNIT 5: OCEAN TECH STORYLINE**  In **Lesson 1**, students will imagine and design ideas for how the Nuu-Chah-Nulth First Nations were able to retrieve valuable shelled animals, called dentalia, from 60 feet deep in the sea to use as currency – up to 2,500 years ago. This To figure out this phenomenon, students will draw their own design of technology that could have done the job. In a reflection exercise, students will learn the term engineering and realize that not only were coastal peoples engineering since time immemorial, but they themselves just achieved the first step of the process, too! With their confidence and creativity piqued, you will present the design motivation: how to access marine debris in the subtidal zone. They will conclude Lesson 1 by defining and delimiting the problem they perceive and generating their first wild ideas for how to solve it.  Once the problem is defined, Explore Teams will launch into the design process in **Lesson 2** to build a prototype of a remotely operated vehicle that can carry out their defined mission. Revisions will be made all along the way, but there is a special focus in **Lesson 3** on employing balanced and unbalanced forces to achieve neutral buoyancy (floating just below the surface) and directional motion.  If feasible, in **Lesson 4**, you will take functional ROVs to execute the mission at a dock, subsequently putting every Science and Engineering Practice to work. Finally, students will make evidence-based recommendations for ensuring or improving subtidal habitat.  Keep all student journals, along with those from each unit you choose to implement. In Unit 8, Salish Sea Heroes, you and your class will select and conduct the best of their evidence-based recommendations for environmental improvement to put into action, becoming Salish Sea Heroes.  If you can’t get enough ROV action, take this unit further by joining a regional ROV competition, such as MA[TE (w](http://www/)w[w.](http://www/) materovcompetition.org) or Sea Perch (www.SeaP- erch.org). If you do, be sure to follow their specific guidelines.  *Icons in this curriculum are from:*  <a href="https://www.flaticon.com/free-icons/chemistry" title="chemistry icons">Chemistry icons created by Freepik - Flaticon</a> | **NGSS PERFORMANCE EXPECTATIONS**  blue=Practice orange=DCI green=Crosscutting Concept  [3-5-ETS1-1](https://www.nextgenscience.org/pe/3-5-ets1-1-engineering-design) Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.  [3-5-ETS1-2](https://www.nextgenscience.org/pe/3-5-ets1-2-engineering-design) Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.  [3-5-ETS1-3](https://www.nextgenscience.org/pe/3-5-ets1-3-engineering-design) Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.  **BRITISH COLUMBIA SCIENCE CURRICULUM**  Grade 5 Big Idea - Machines are devices that transfer force and energy  Grade 5 Content – Constructed Machines   * The nature of sustainable practices around BC’s resources * First Peoples knowledge of sustainable practices   **If using this content for grades 6-8:**  [MS-ESS3-1](https://www.nextgenscience.org/pe/ms-ess3-3-earth-and-human-activity) Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.  [MS-ETS1-1](https://www.nextgenscience.org/pe/ms-ets1-1-engineering-design) Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.  [MS-ETS1-2](https://www.nextgenscience.org/pe/ms-ets1-2-engineering-design) Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.  [MS-ETS1-3](https://www.nextgenscience.org/pe/ms-ets1-3-engineering-design) Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.  [MS-PS2-2](https://www.nextgenscience.org/pe/ms-ps2-2-motion-and-stability-forces-and-interactions) Plan an investigation to provide evidence that the change in an objects motion depends on the sum of the forces on the object and the mass of the object. | |
| **LEARNING TARGETS LESSON 1**   * Know that engineering has been practiced to develop marine technology since time immemorial in the Salish Sea. * Identify ourselves as engineers after experiencing the first steps of the process of engineering * Define and delimit a problem related to accessing the seafloor without getting in the water.   **TEACHING WITH THE 5 E’s FOR A COHERENT STORYLINE – LESSON 1**  ENGAGE activity: Students imagine how the Nuu-Chah-Nulth First Nation may have gathered dentalium shells from deep in the sea.  **Practice**: Constructing explanations and designing solutions, Developing models.  EXPLORE activities: Students design the technology they think the Nuu-Chah-Nulth dentalium shell gatherers may have used and explore other students’ designs in a friendly competition for the most feasible ocean tech. for the job.  **Practice:** .  EXPLAIN activity: Students figure out the definition of engineering, based on the design activity they did, and explain in a reflection that both they and the Nuu-Chah-Nulth dentalium gatherers were practicing engineering.  **Practice**: Constructing explanations.  ELABORATE activity: Wonder at plastic waste on the seafloor out of reach in the present day. Define the problem that might be helped with modern ocean technology.  **Practice**: Asking questions and defining problems.  EVALUATE activity: Consider all proposed problems and evaluate which is the most important and feasible to address using ocean technology they could engineer.  **Practice**: Communicating and Evaluating Information | **TERMS FOR THE TEACHER**  A picture containing text, sign  Description automatically generated**Assessment**- a chance to measure overall growth through a pre- and post-assessment for each unit.  **A picture containing object, mirror  Description automatically generated**  **Background research**- includes the Explore the Salish Sea book, articles, videos, games, songs, and expert guests.  Shape  Description automatically generated with low confidence**Essential question** – The overarching question that drives the background research, games, activities, and authentic inquiry for each unit.  Checkbox Checked with solid fill  **Formative Assessment** – opportunity to check for student understanding and misconceptions.  **Games-** games are used to introduce and reinforce concepts through play. Instructions are included.  **Diagram  Description automatically generatedMind Map** – Draw a model with the problem in the center circle and clues to solving it connected to it, grouped by related ideas.  **Model** – A physical, mathematical, or conceptual representation of an object, process, or event  **Text  Description automatically generated**  **Team Read** – The equitable division of a large piece of literature among teammates, each getting summarized individually, and then synthesized into one summary. This allows each student to feel that they have contributed an important piece of background research, while accommodating individual reading levels.  A picture containing icon  Description automatically generated  **Tribal Knowledge** - Work with your district’s Tribal Liaison to invite a class visit from a cultural outreach or natural resources employee from a local tribe or First Nation to share *what they deem appropriate* about the topic.  **A picture containing text, sign, dark  Description automatically generatedWonder** – a phenomenon, problem, or discrepant event that sparks curiosity in students and initiates exploration | |
| **TEACHER PREP LESSON 1**   * Review unit plan, student journal, and slideshow together. Revise these as desired and appropriate for your community and ecosystem. Decide if you will engineer working, submersible ROVs. If this is not feasible, there is a model ROV engineering challenge, thanks to Ocean Networks Canada (Thank you, ONC!). Journal pages are included for the model ROV challenge. If you will not be using this option, remove these journal pages (pp11-14) before printing and adjust journal page numbers in this teacher guide accordingly. * Print desired journal pages * Print the Ocean Tech [pre-assessment](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EX_DlcQWOLZOj-NLDb0ZkbkBYjTiQpLVAKvOXNxwpXME3g?e=7ygCWf) or prepare to administer electronically. * Print one copy for yourself of the Snively (2009) article. * Print instructions and cards for the [Salish Sea Subtidal Shuffle Game](https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/ERbCgc2liw5KuCbOUtjlt30BokT8D1YPMLmKuYeZfhAvBA?e=UNc4pT) * Connect with a community partner who can support the engineering design process and the ROV mission with guidance and/or materials. [Ocean Networks Canada](https://www.oceannetworks.ca/learning/youth-programs-k-12/) is one such partner and can introduce ocean technology or host a field trip before engineering your own model or working ROVs. They are available for live, virtual programs outside of BC. * Order one already wired [Angelfish ROV kit](https://seamate.org/collections/angelfish-rovs/products/angelfish-rov-kit-with-thrusters-and-tether?variant=32765937713223) ($290 each). Consider a grant or PTA fund with a STEM or engineering-specific earmark. * Organize one ROV materials kit in a [storage bin](https://www.costco.com/greenmade-27-gallon-storage-bin%2c-4-pack.product.4000205525.html) for each Explore Team (5-6 bins per class of 30 students).      * Identify a location for students to test ROV prototypes for buoyancy. If a body of water or water tank isn’t accessible on school property, use [three storage bins](https://www.costco.com/greenmade-27-gallon-storage-bin%2c-4-pack.product.4000205525.html) filled with water outside or in the classroom. * Plan ahead for a field trip to conduct the main mission. If you plan to guide students to observe and collect trash, consider connecting with a local boating center or [Marine Resources Committee](https://nwstraits.org/get-involved/marine-resources-committees/) to find a good location. * Review unit vocabulary (see student journal pp.5-6) and consider ways you will weave the use of these words naturally through the lessons. Students will return to define them opportunistically as they become familiar through use. * Option: Work with your district’s Tribal or First Nations Liaison to invite a cultural outreach or natural resources employee to visit your class and share what they deem appropriate on the topic of how their community engineered ocean technology in the past and how they do in the present. * Decide on Explore Team composition. It works best to have mixed ability groups, where students may contribute their individual strengths to the team and support one another where needed. If you haven’t already, label spots at each table with Explore Team titles (see student journal p2). When rotating roles, students can rotate seats within their existing team or within a new team altogether * Print ROV survey of First Nations foodscapes article by Buscher et al. (2020), 1 per student or pair of students. Divide equitably by the number of students in each team for a Team Read activity. | | |

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| **MATERIALS LESSON 1**  Session 1 ENGAGE   * Printed and cut Pearls of Wisdom and a seashell to hold them (optional) * Internet connection\* * Audio/Visual equipment and the Ocean Tech Slide deck \* * Teacher Guide, print a copy if desired, have electronic version available for weblinks\* * 1 printed pre-assessment for each student * 1 student journal for each student plus 1 for you to mark up and follow along\* * 1 copy of Explore the Salish Sea: A Nature Guide for kids for each student * 1 copy of Money from the Sea article by Snively 2009.   \*Used in all sessions  Session 2 EXPLORE   * Colored pencils, 1 pack per team * Gloria Snively article * Designated wall space for a gallery walk   Session 3 EXPLAIN   * Just journals   Session 4 ELABORATE   * Salish Sea Subtidal Shuffle Game, 1 set per team * ROV survey of First Nations foodscapes article, divided into parts for a Team Read * [Team read template](https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/EU5iyegzsftDon8BNMT_dVMBTn8O5ggLUV_AfC9heyegKw?e=hPbgzP), drawn onto poster paper, 1 per Explore Team * Colored markers for each team member to use a different color on the Team Read poster. | **WEBLINKS LESSON 1**  Pearls of Wisdom - <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EXNaWDydtMJItP9Ml4PdIycBDEx4RIijSixRcotTpXbuQA?e=0BEQ14>  Ocean Tech Pre-assessment <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EX_DlcQWOLZOj-NLDb0ZkbkBYjTiQpLVAKvOXNxwpXME3g?e=7ygCWf>  Ocean Tech Slideshow - <https://pacificeductioninstitute.sharepoint.com/:p:/s/Program/Ed6ssDqFAWtJj9mKdKKZwPoBDHXiqfJXQxmN87TZR7fHAg?e=DSKeCi>  Ocean Tech Student Journal - <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EVY-QGpww5ZIlxKfecmbvyIB1TaZtcbY4PxfSWx5MNjZNg?e=xQZgsf>    Money from the Sea article by Snively 2009  <https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/EYZ1ocnrvrpPvXvbifsdfvAB5b3H08o7Satd-HX6W7xxmA?e=3wixuP>  ROV survey of First Nations foodscapes article  <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/ERH7ePmIz6dHgflUR6_D7UwBqTnVBez66KiMnXRdXygbyw?e=pOUagv>  Team Read Instructions and template  <https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/EU5iyegzsftDon8BNMT_dVMBTn8O5ggLUV_AfC9heyegKw?e=hPbgzP>  Ocean Networks Canada Education Coordinator Contact for virtual field trips and presentations  https://[www.oceannetworks.ca/about-us/organization/staff/Lauren-Hudson?staffer=Hudson%2CLauren](http://www.oceannetworks.ca/about-us/organization/staff/Lauren-Hudson?staffer=Hudson%2CLauren)  Ocean Networks Canada ROV footage video 1 <https://www.youtube.com/watch?v=Oq3Cko9mgMA&feature=emb_logo>  Ocean Networks Canada ROV footage video (ROV picking up a VHF radio) <https://pacificeductioninstitute.sharepoint.com/:v:/s/Program/EU32ZMvLpwBJjLW7UCpKFboB9z8mbJ7tEZ_sqiNegM7KBg?e=rYBgnb>  Ocean Networks Canada ROV Pilots Wanted lesson <https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/ET9EewDC33BGjjc8KdrOBqcB_UPL0AcvN5M0cMz9hidLsg?e=rPfZfF>  Ocean Networks Canada ROV Pilots Wanted activity cards  <https://pacificeductioninstitute.sharepoint.com/:p:/s/Program/Eaao6DXoJvRHgVZFkMiHyjgB0jRrqC7pS7d2IT2B6-7aMA?e=Xdh0da>    Salish Sea Shuffle Game <https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/ERbCgc2liw5KuCbOUtjlt30BokT8D1YPMLmKuYeZfhAvBA?e=d7UAeA>  Essential Question description    Extensions for Ocean Networks Canada:  Oceans Network Canada ROV Grabbing Arm activity <https://www.oceannetworks.ca/sites/default/files/images/pages/learning/OnlineResources/ROV%20Grabbing%20Arm.pdf>  ONC education resources: <https://www.oceannetworks.ca/learning/resources/learningathome/K-12%20Resources> |

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| TIME | **TEACHER GUIDE LESSON 1** How can we define the problem of subtidal marine debris? |
| Session 1  1 MIN  <1 MIN  5 MIN  20 MIN  20 MIN  5 MIN  (55 MIN session) | **ENGAGE**   1. Provide [pearls of wisdom](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EXNaWDydtMJItP9Ml4PdIycBDEx4RIijSixRcotTpXbuQA?e=yfFaFx) in a large shell for a student to draw from and read aloud. 2. Introduce Unit 5, Ocean Tech, **slide 7** 3. A picture containing text, sign     Description automatically generatedForm or rearrange **Explore Teams, journal p3, slide 8**. 4. Administer the Ocean Tech [pre-assessment](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EX_DlcQWOLZOj-NLDb0ZkbkBYjTiQpLVAKvOXNxwpXME3g?e=YWF9IP), **slide** **9**. 5. A close up of a flower     Description automatically generatedInvite students to immerse themselves in the subtidal world, reading Explore the Salish Sea chapter 5, Life in the Deep: The Subtidal World, **slide 10**, independently or with a reading partner. Distribute student journals. Have students write names on the front. When finished invite them to free-write inspired thoughts on **journal p4**. They should highlight or circle unfamiliar vocab words on **journal p5**. They can come back and write definitions as they learn them through repeated use throughout the unit. Encourage this opportunistically as you go.      1. **Wonder**: Ask students what else they think is on the seafloor alongside the amazing wildlife they just saw in the book. Show **slide 11** (a plastic bag on the seafloor) and ask students to write and/or draw what this makes them wonder on **journal p6**.   Paint brush with solid fill  \*\* Art extension – add the subtidal zone to your wall mural, using information and images from this chapter during art time. |
| Session 2  10 MIN  15 MIN  15 MIN  10 MIN | **EXPLORE**   1. A picture containing icon     Description automatically generatedLet students know that getting items from the seafloor without getting cold and wet has been a challenge coastal peoples have overcome since time immemorial! And that you have a story of something valuable a coastal First Nation on what is now called Vancouver Island gathered from the seafloor, starting over 2,500 years ago. In fact, it was so valuable it was used as money across much of North America! Show **slides 12 - 14** and share the information in the presenter notes with your students. Share as much of the story from the [Snively (2009) article](https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/EYZ1ocnrvrpPvXvbifsdfvAB5b3H08o7Satd-HX6W7xxmA?e=WVeNJs) as you have time for, but don’t reveal the technology actually used to gather the shells. 2. Ask students to consider how they think the “money from the sea” dentalium shells were gathered and challenge them to design technology they would use to gather them with only the materials available to the Nuu Chah Nulth and Kwakwa- ka’wakw engineers 2,500 years ago, **slide 15** (Design Challenge). Hold a light-hearted competition for the most viable idea, having students describe, then draw and label a diagram on **journal pp7-8**, **slide 16**. 3. Have students post these designs in the designated wall space for a Gallery Walk when they are finished. Invite students to the gallery to consider which design has the most feasible technology for dentalium collection, voting for one winner. Suggested award: First choice of Engineering Roles for an upcoming marine engineering project (don’t share about ROVs yet).   **EXPLAIN**   1. Conclude the challenge by having students answer reflection questions on **journal p9**. These questions establish that, not only have the coastal First Nations peoples been engineers since time immemorial, but that the students themselves have just engaged in the first steps of the engineering process! They are now ready to take on a modern day ocean technology engineering challenge. Wrap up by having them consider the question at the bottom of **journal p9**. |

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| TIME | **TEACHER GUIDE LESSON 1 continued** |
| Session 3 10 MIN  35 MIN  5 MIN | **ELABORATE**   1. Show **slide 17** and use presenter notes to discuss that 95% of the ocean is still unexplored. Ask students what they know about how oceanographers explore places where it is not safe to dive. Allow a few popcorn-style responses. Show **slide 18**, a repeat of the marine debris on the seafloor. Ask what they wondered about this plastic on the seafloor. Ask if there is likely to be similar marine debris at \_\_\_\_\_\_\_ (fill in with a popular marine access site in or near your community). Ask how they might access this marine debris and what they would do if they could.   **A picture containing object, mirror  Description automatically generated**   1. Suggest they will need some background information about subtidal wildlife and their habitat needs, **slide 19**, to inform their ideas about this issue, and what better way to learn than through a game? Game Break! **slide 20.** Introduce and distribute card sets for the game, Salish Sea Subtidal Shuffle, by Daniel Lombardo. 2. Have Lab Techs direct putting away the game. |
| Session 4  25 MIN  10 MIN  5 MIN  10 MIN | 1. **A picture containing object, mirror     Description automatically generated**Show **slide 19** again and share that an important way scientists gather background information is by reading what mysteries other scientists have revealed. Scientists share about their studies in scientific articles, such as this one: Distribute the [article about ROV surveys of First Nations foods](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/ERH7ePmIz6dHgflUR6_D7UwBqTnVBez66KiMnXRdXygbyw?e=iinisi) and divide amongst Explore Team members equitably, based on reading levels. A lower reading level text is provided [here](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EV2M3QPB_25DpsxSDvNJwjABw90ce-W0LJNFSh9pF2yPdQ?e=2iTmxF). Provide a Team Read template on poster paper for each team. Have each Science Communicator share their team’s summary of the article. Emphasize the connection between ocean engineering in ancient times vs. engineering in modern times.   **EVALUATE**A picture containing sign, dark  Description automatically generated   1. Equipped with background information about subtidal life from the game, the role of technology in protecting First Foods in this article, and the image of the plastic bottle on the seafloor, give time here for students to take the first step in the engineering process: *Identify the problem*. Have them do so by considering and writing answers to questions 1-3 on **journal p10**. 2. Invite Explore Teams to hold a ***Team Talk*** to share their answers to #3 then evaluate each person’s suggested ideas for what the problem is and how they would solve it using ocean technology.      1. Have each team’s Science Communicator report their problem-solving mission idea to the class and support them combining ideas and distilling them into one Essential Question that everyone records, **slide 21, journal p10**. |

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| **LEARNING TARGETS LESSON 2**   * Design a prototype of ocean technology that will help you reach the seafloor and communicate your design to your Explore Team. * Select or combine design ideas into one design for your Explore Team. * Build your first prototype of a remotely operated vehicle. * Test your team’s prototype ROV against competing designs from other teams.   **TEACHING WITH THE 5 E’s FOR A COHERENT STORYLINE – LESSON 2**  ENGAGE activity: Students design solutions to their identified problem of reaching the seafloor in the subtidal zone  **Practice**: Designing solutions, Developing models.  EXPLORE activities: Students select the design within their team that would best meet the mission and build their first prototype ROV  **Practice:** Constructing explanations and designing solutions.  EXPLAIN activity: Students problem solve issues with their first ROV prototype test, describe what worked well and not so well in their journals, and revise their designs.  **Practice**: Evaluating and communicating information, Engaging in argument from evidence, Constructing explanations.  EXTEND activity: Students test newly redesigned prototypes against one another using controlled variables.  **Practice**: Planning and carrying out investigations.  EVALUATE activity: Rate your ROV performance using a rubric. Identify areas for improvement.  **Practice**: Communicating and Evaluating Information, Constructing explanations and designing solutions. | **NGSS (WSSLS) ADDRESSED LESSON 2**  Three Dimensions of NGSS  **blue=Practice orange=DCI green= Crosscutting Concept**  [3-5-ETS1-2](https://www.nextgenscience.org/pe/3-5-ets1-2-engineering-design) Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. |

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| **TEACHER PREP LESSON 2**  In this section, students will re-design and test ROVs for balance and neutral buoyancy with their motors mounted. They will record progress and compare competing design ideas to select the best one for their mission. Results and possible frustrations from Part 2 will build a desire to better understand forces acting on the ROVs, the topic of Lesson 3.   * Confirm with [Ocean Networks Canada](https://www.oceannetworks.ca/learning/youth-programs-k-12/) or another engineering organization or individual if you invited them to introduce ocean technology or scheduled a field trip before engineering your own model or working ROVs. * Set up materials for the [Human ROV game silent version](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EeI26kzGOhxFg5bPkhFkHrQBkJFNyYnBxR1INsR-QIPIHw?e=98xa8u) * Designate a space for ROV and tool kit storage for each team. Set out tool kits in this space.   \*\*\**add photo of assembled ROV tool kit here*   * Set out ROV materials bins for easy access. Materials listed on the following page. * Prepare a test tank, such as a Rubbermaid bin, stock tank, or small swimming pool with water at least 1.5 feet deep. Provide towels for drying ROVs and mopping up splashes and drips. * Designate a space for ROV materials, sorted by type, to be available for the Lab Techs to retrieve necessary parts.   \*\*\**add photo of ROV materials set-up here*  **ROV Pilots Wanted Alternative Option**  If you are not able to build actual, submersible ROVs, you will be using the Ocean Networks Canada ROV Pilots Wanted alternative in which students engineer a model ROV (thank you, ONC!!!). You will be meeting the same engineering standards…and getting a lot less wet in the process.   * For this option prepare the following:   + Arrange for a virtual introduction by Ocean Networks Canada or another ocean technology organization, if possible.   + Review the [ROV Pilots Wanted activity description](https://ucdavis.box.com/s/sqq5d1u09rlmt3v8ej2lixjy23cg8aos) and gather materials:   + One piece of recycling of their choosing   + An arm’s length of masking tape for construction   + 8 popsicle sticks   + 2 chopsticks/bamboo skewers (to hang the ROV)   + 1 piece of white   + paper   + 30cm of yarn   + 6 paperclips   + Scissors   + Pen/pencil * Suggested supplies for ROV tasks:   + A few cups of flour   + Cookie sheets   + Large bag of marshmallows or gummy bears   + A few blindfolds   + Designate space and set up materials for the ROV obstacle course, following the description in the link above. |

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| **MATERIALS LESSON 2**    All sessions:   * ROV tool kits, 1 per team with:   + Flathead screwdriver, Phillips screwdriver   + Ratcheting pvc cutter or hack saw   + Needle nose pliers * Ruler * Electrical tape (\*note: duct tape is not waterproof) * Wire strippers * re-usable zip ties small and large ([this is a link to an example at Home Depot](https://www.homedepot.com/p/Cambridge-8-in-Releasable-Cable-Ties-Black-20-Pack-CT12796/303059758?source=shoppingads&locale=en-US&mtc=Shopping-B-F_D27E-G-D27E-27_11_TOOLS_And_ACCESSORIES-NA-NA-Feed-SMART-NA-NA-New_Engen&cm_mmc=Shopping-B-F_D27E-G-D27E-27_11_TOOLS_And_ACCESSORIES-NA-NA-Feed-SMART-NA-NA-New_Engen-71700000072501775-58700006340111859-92700057208561306&gclid=CjwKCAiA9vOABhBfEiwATCi7GDIm5cCpcvbh22eeGJOQjYWNEvQe4ce4eVIRz0wqyBWt9lAg2dAf-RoC2roQAvD_BwE&gclsrc=aw.ds)). * Place all tools in a toolbox. Teams can label and keep for the unit. You will add tools to tool kits as needed. * 1-2 per class: soldering iron, solder, hot glue gun, heat gun, multimeter (for testing circuitry) * SeaMATE AngelFish ROV kits or similar kits, one per Explore Team, ($220 each in 2022) \*Approach schools foundation, community partners, or private donor for funding, if this is not in your class budget. Funds for engineering education abound! * motors and motor mounts (with SeaMATE kits)   (building motors and controllers from scratch is possible but will require much more time than is allotted in this guide.   * ballast materials, such as stainless-steel nuts or large washers, fishing weights, etc., a few per kit.   ROV frame material:   * pvc pipe from or other study frame material. This can be pre-cut into lengths varying from 5-30 inches. Provide enough for each Team to have at least 6 pairs of same- length pieces. Additional pieces can be cut on request by adult or supervised students. * pvc joints in a variety of side-out corner pieces 90° elbows, crosses, couplings, and end caps-at least 4 per team * Test tanks-use the largest container you have available. Reach out to community members to contribute, inquire with your local pool or nearby marine science center to use the facilities for testing day (field trip), If staying at school, athletic icing/ soaking tubs or stock tubs work well. Even a large Rubbermaid®-style bin will do in a pinch.   **Running ROVs with motors**   * Instructions and printed diagrams for motor and switch board assembly * Marine, deep cycle battery or other waterproof power source   ***\*Sustainability Stars: repurpose used materials that students bring from home for ROV building materials.*** | **WEBLINKS LESSON 2**  Ocean Tech Slideshow - <https://pacificeductioninstitute.sharepoint.com/:p:/s/Program/Ed6ssDqFAWtJj9mKdKKZwPoBDHXiqfJXQxmN87TZR7fHAg?e=LK53mz>  Ocean Tech Student Journal  Human ROV Game silent version  <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EeI26kzGOhxFg5bPkhFkHrQBkJFNyYnBxR1INsR-QIPIHw?e=98xa8u>  There are many resources for this unit provided by the MATE websites. Spend some time exploring them!    SeaMate ROV curriculum:  https://[www.marinetech.org/rov-curriculumoutline/](http://www.marinetech.org/rov-curriculumoutline/)  Order your MATE ROV Kit here:  https://[www.marinetech.org/angelfish-kit/](http://www.marinetech.org/angelfish-kit/)  MATE AngelFish ROV Kit instructions <https://www.marinetech.org/files/marine/files/Store/AngelFish/AngelFish%20instructions%205_Final.pdf>  NOAA ROVNautilus live stream video  <https://nautiluslive.org/video/2015/04/15/rare-sperm-whale-encounter-rov>    Fun ROV video: <https://www.youtube.com/watch?v=gbNWm-n-DZQ&list=PL6F7C5F27E155F090&index=2>  ONC education resources: <https://www.oceannetworks.ca/learning/resources/learningathome/K-12%20Resources>    **Human ROV Game materials**   * For each Team: * 10’ length of yarn, rope, or survey ribbon for “tether” * 40’ length of rope to enclose the “sea” (game area) * Small, soft object for ROV to retrieve, such as plush toys * Eye covering |

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| TIME | **TEACHER GUIDE LESSON 2** What are solutions for reaching garbage in the subtidal zone? |
| Session 1  10 MIN  5 MIN  15 MIN  5 MIN  5 MIN  10 MIN | **ENGAGE**  *\*Note: here is where you may elect to run Ocean Networks Canada’s* ***ROV: Pilots Wanted*** *challenge in place of engineering a working, submersible ROV. Journal pages are included for this challenge and you will proceed through this lesson with the only difference being the end product. If you choose to go straight to engineering working ROVs, skip journal pages 21-14, if you haven’t already removed them during unit prep.*   1. A picture containing graphical user interface     Description automatically generatedAsk Explore Teams just how they can envision reaching the seafloor to solve/answer their essential question, **slide 22.** Have Lab Techs pick up colored pencils for their teams and allow 15 minutes for each student to sketch a diagram on **journal p11** of their initial idea for marine technology that could run the mission to solve the problem they defined at the end of Lesson 1. Encourage wild, zany, nearly impossible ideas that just might work. 2. A picture containing sign, dark     Description automatically generatedHold a ***Team Talk*** for each student to share their designs within their teams. Afterward, call on the Science Communicators to share some creative highlights with the class. 3. Offer some hope that reaching the seafloor is possible by sharing **slides 23-24** (if ocean engineers can develop technology to reach the deepest part of the whole ocean, we can surely reach the bottom of the nearest bay!). Share additional background information and inspiration from Ocean Networks Canada’s **slides** **25-33. (Note: Schedule the ONC visit here, if applicable).** Afterwards, ask if an ROV is the best ocean technology to fulfill their mission. Now that you have used the term ROV several times in context, this is a good time to return to the unit vocabulary, **journal p5** to write/draw a definition, based on their experience. 4. Ask students to review their mission (**journal pp12-14, slide 34** for the model ROV, **journal p10, slide 35**  for the working ROV). Go over the engineering process within their teams, **slide36**. Call on students to read each step of the process out loud, repeating, “Fail Soon, Fail Often!” after each step, **journal p15**. Emphasize failing as an integral part of engineering and sparks improvement. 5. Ask if they are ready to take it to the next level as engineers. If so, teams should select an ROV Team Name and Engineering Job Titles, **slide 37**, **journal p16**. Fill in all names. Tell them that **journal pp 17-18** are for recording a map of their engineering process as they go. Ask which steps they have already experienced in the Money from the Sea challenge and in sketching their initial ideas for meeting the mission, as well as where they are now. They will return to it each day to track their process. 6. A picture containing graphical user interface     Description automatically generatedInform the class that each team will engineer just one ROV, allow them to see the materials each team may access, including motor assemblies. Allow time to select the ROV design, or combine designs, from within their team that they will build into a prototype ROV to test. They should sketch that design on **journal p19,** including motors. |
| Session 2  20 MIN  10 MIN  10 MIN  10 MIN | **EXPLORE**   1. A picture containing graphical user interface     Description automatically generatedAsk that each team’s Chief Structural Engineer review the team’s ROV design from last session, **journal p19**, and send the Lab Techs to retrieve the building materials for the team to build their first prototype. Have the Chief Structural Engineer work with the CCO and CFO to build the ROV frame. Ask the Chief Electrical Engineers to work with the Chief Mechanical Engineers to assemble the control boxes (for a working ROV). 2. The Chief Structural Engineer should mount the motors, according to the ROV design, minding the way that the tether (wires to the control box) will sit within the ROV when in the water. These should be out of the way of the propellers and any other moving parts. 3. A picture containing graphical user interface     Description automatically generatedAllow teams to test their ROVs in the test tub or tank to ensure neutral buoyancy (floating just beneath the surface without sinking) and to ensure a balanced structure. The Mechanical Engineers should add weights as needed for ballast to achieve an ROV that floats evenly below the surface. Electrical tape may be added to joints to make them water proof. An ROV that fills with water is okay if that is part of the design.   **EXPLAIN**   1. Ask Lab Techs to lead their Team in clean-up/storage of ROVs/materials. When finished, hold a Team Talk and fill in their ROV Design Log 1 on **journal p20.** |
| Session 3  (65 min)  20 MIN  5 MIN  10 MIN  20 MIN  10 MIN | **E****LABORATE**   1. Optional Game Break: Introduce and explain the [Human ROV Game, Silent Version](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EeI26kzGOhxFg5bPkhFkHrQBkJFNyYnBxR1INsR-QIPIHw?e=UoWNkM), **slide 38**. Emphasize the main idea: ROVs can only do what they are signaled to do. 2. A picture containing graphical user interface     Description automatically generatedReturn to the ROV designs and have each student add a small sketch of their current (initial) design to the lavender DESIGN circle on **journal p17**. Have them also add a sketch to the orange, EXPLORE circle, showing how they tested this design in the last session.   A picture containing graphical user interface  Description automatically generated   1. Hold a Team Talk to refine the design. Now that they have experienced what does and doesn’t work, invite teams to build two improved, distinct prototypes to test against one another. Sketch both prototypes on **journal p21**. 2. A picture containing graphical user interface     Description automatically generatedAllow teams to build and test their revised prototypes (they will only have one set of motors, so they will have to test and re-mount one ROV at a time. Variables to test for at this stage include neutral buoyancy, floating balanced, motion up, down, forward, aft, and left and right. Students should rate their prototype candidates on **journal p21**.   A picture containing sign, dark  Description automatically generated **EVALUATE**   1. Allow a few minutes for Lab Techs to direct ROV clean-up then hold a ***Team Talk*** to reflect and have all students complete the ROV Design Log 2 on **journal p22** and draw or write about the testing in the orange “Try It Out circle, **journal p15.** |

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| **LEARNING TARGETS LESSON 3**   * Understand that opposite forces are acting on every object. * Know that motion occurs due to unbalanced forces. * Understand that an object displaces an amount of water equal to the mass of the object. * See that when an object’s mass is spread out in water, a greater area of water is exerting upward (buoyant) force on the object   **TEACHING WITH THE 5 E’s FOR A COHERENT STORYLINE – LESSON 2**  ENGAGE activity: Observe the stability and control of a NOAA ROV at work and compare to our own working prototypes.  **Practice**: Defining problems  EXPLORE activities: Investigate effects of balanced and imbalanced forces on various objects in 5 “May the Force be with You” stations.  **Practice:** Using models, Obtaining, evaluating, and communicating information.  EXPLAIN activity: Reflect on the effects of Newton’s Laws on the objects in the station activities and draw similarities to our working ROVs.  **Practice**: Constructing explanations and designing solutions.  ELABORATE activity: Apply design revisions to ROV prototypes based on force and motion station reflections.  **Practice**: Designing solutions.  EVALUATE activity:  **Practice**: Evaluating and communicating information, Constructing explanations and designing solutions. | **NGSS (WSSLS) ADDRESSED LESSON 3**  Three Dimensions of NGSS  **blue=Practice orange=DCI green= Crosscutting Concept**  [3-5-ETS1-3](https://www.nextgenscience.org/pe/3-5-ets1-3-engineering-design) Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.  [5-PS2-1](https://www.nextgenscience.org/pe/5-ps2-1-motion-and-stability-forces-and-interactions) Support an argument that the gravitational force exerted by Earth on objects is directed down.  [MS-PS2-2](https://www.nextgenscience.org/pe/ms-ps2-2-motion-and-stability-forces-and-interactions) Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. |

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| **TEACHER PREP LESSON 3**  Lesson 3a uses hands-on manipulatives to help students build their own concepts of the effects of Newton’s Laws of Motion experientially.  You will prepare Explore Stations for students to discover gravity, buoyant force, propulsion, friction, compression and expansion, and displacement.   * Arrange for a parent volunteer to monitor and support each station, if possible. If not, these can be student-directed. * Set up 5 Exploration Stations following the [May the Forces be With You instructions](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EfBELw7yVB9EosLdWD0l7f4Bwk2P9-6EZ1GMZ3iZqUYBQw?e=obWh4C)   Materials are listed on the next page and in the instructions document.   * Cue [NOAA ROV Nautilus video](https://nautiluslive.org/video/2015/04/15/rare-sperm-whale-encounter-rov) |

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| **MATERIALS LESSON 3**    May the Forces be With You Stations  Station 1:   * One rubber duck per student at the station * One container to hold enough water to fit 4-5 rubber ducks * Water to fill the container   Station 2:   * One balance (triple beam balance or electric balance) to measure mass * 500 mL plastic or glass beaker with volume measurements, 1 per student at station * Two 15 x 15 cm pieces of aluminum foil per student at station (these should have equal masses) * 10 or 20 mL graduated cylinder for pouring out the displaced water, 1 per student at station * Long forceps (tweezers) to remove aluminum from beaker.   Station 3:  Per pair of students at station:   * One 1-L or smaller, clear, squeezable plastic water bottle * One glass eye dropper * 2 empty balloons * Source of water * triple beam or electric balance to measure mass   Station 4:  For each pair of students at the station:   * Some open space for flying toy airplanes * Rubber band-powered, propeller airplane   Station 5:   * One card stock triangle, at least 20 cm on one side * One card stock paper airplane * One toy boat, any material * Each team’s ROV   ***\*Sustainability Stars: repurpose used materials that students bring from home for ROV building materials.*** | **WEBLINKS LESSON 3**    NOAA ROVNautilus live stream video    Exploration Stations: May the Forces be With You Instructions <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EfBELw7yVB9EosLdWD0l7f4Bwk2P9-6EZ1GMZ3iZqUYBQw?e=obWh4C>  Newton’s Laws of Motion video by MooMoo Math and Science <https://www.youtube.com/watch?v=PIQlPTkcKvk>  Optional extensions:  Adding sensors to your ROVs  Camera <https://www.marinetech.org/files/marine/files/Store/Accessories/AmazonCameraParts3.pdf>    Building a Hydrophone |

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| TIME | **TEACHER GUIDE LESSON 3:** How can we put balanced and unbalanced forces to work for operating our ROV? (aka: May the Forces Be With You!) |
| Session 1  5 MIN  5 MIN  5 MIN  35 MIN | **ENGAGE**   1. Show this NOAA ROV Nautilus footage a very surprising encounter for fun and inspiration: NOAA video, **slide 39**. Ask students if they noticed how steady, balanced, and controlled the ROV movements are, even when they meet a leviathan! 2. Checkbox Checked with solid fillDiscuss the last testing results briefly as a class, according to **journal pp21-22**. Ask for a thumbs up, sideways, or down in response to whether there were any challenges with keeping their ROVs balanced and under smooth control (balanced and under control = thumbs up). Ask if any of their prototypes received an Pass for any of the test variables (thumbs up = Pass). Testing will have likely shown design failures in one or both of each team’s prototypes (this is good!). 3. A picture containing sign, dark     Description automatically generatedMany issues in the first ROV trials were likely caused by unbalanced forces acting on the ROVs. Invite students to hold a ***Team Talk***:    1. What forces might be acting on your ROV?    2. What things are pushing, pulling, or resisting our ROV as it sits or moves in the water?    3. Have students draw arrows pointing in the direction of each force on the sketch of their most recent ROV, **journal p21**, each arrow representing a force and pointing in the direction that the force is pushing or pulling. They will return to these diagrams after the May the Force be With You activity to revise their arrow placement.   **EXPLORE**   1. Suggest that playing with the objects in the 5 stations set up around the room may just be the ticket to tackling their design flaws. Direct students to Exploration Stations, **slide 40**. Allow 1-2 Explore Team per station for 7 minutes each. Have students follow instructions on the “Try This” card at each station and write station observations on **journal p23.**   STATION 1: Equal & Opposite Forces, Just Ducky! STATION Idea: Equal forces, buoyant force and gravity, keep the duck in place  STATION 2: Measure mass of object and mass of water displaced by object (rubber ducky) STATION Idea: Displacement Moves an Equal Mass of Water. Spreading the mass of an object out over more area  STATION 3: Balloons with diff. masses. Diver (plastic bottle with eye dropper filled with air in it or another air-filled item). Squeeze to sink, release to float. STATION Ideas: 1. Gas (air) has mass. 2. Increasing water pressure compresses air in submerged objects, causing negative buoyancy. Decreasing water pressure allows air to expand, causing positive buoyancy  STATION 4: Rubber band-propelled airplanes on a fishing line taped onto the backs of two chairs. STATION Idea: Unbalanced, opposite forces keep the plane in flight: lift>gravity, thrust > friction (air resistance). Energy transfer from spring potential energy (wound up rubber band) to mechanical kinetic energy (spinning propeller) powers the thrust force.  STATION 5: Find the balance point of 3 objects: a large, card stock triangle, a paper airplane, and a toy boat, by holding each up on a pencil eraser. STATION Idea: Every object has a center of gravity, around which its weight is equal. Keeping the center of gravity low will help keep their ROV upright. |
| Session 2  15 MIN  35 MIN  10 MIN | **EXPLAIN**   1. Show the video on Newton’s Laws by MooMoo Math and Science, **slide 41**. Have students complete the review questions on **journal p24** as they talk through it together with their Explore Teams 2. Allow Teams a revise/rebuild session for ROV improvements based on their new understandings of forces and motion. Allow them to test their ROVs in the test bin or tank. 3. Introduce scale and the importance of diagrams being drawn to scale, **slides 42-44**.    1. Have students draw their ROVs to scale, **journal p25**. Then record today’s revisions and observations in ROV Build Log 3, **journal p26**. 4. Collect student journals after this session to assess student understanding of forces and motion. Show video of ROVs dueling in the deep just for fun, **slide 45**. |
|  | Optional extensions:  Nature Detectives Explore Stations: Electricity and Magnetism, **slide 46**.  Procure D-cells, mini lightbulbs, wire, magnets, and a few more simple supplies, to make stations for students to build simple circuits, electromagnets, motors, and draw schematics (circuit diagrams) to help students understand the circuitry of their ROVs. Suggested resources: FOSS Electricity and Magnetism kit.  Introduce schematics to model electric circuits, **slides 47 - 49**.  Build and add sensors to your ROVs, such as a camera, hydrophone, or temperature probe. Resources in weblinks on p. 19 of this guide. |

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| **LEARNING TARGETS LESSON 4**   * Know that the process of science can solve mysteries and problems or explain how things work. * Understand that carrying out a careful-   ly-planned investigation provides data we can analyze using math and creating graphs.   * Know that we can use critical thinking to construct explanations about phenomena and back them up with evidence. * Understand that communicating scientific investigation results is how science is brought to the people to inform decisions that make a difference for helping people and wildlife to have a better life.   **TEACHING WITH THE 5 E’s FOR A COHERENT STORYLINE – LESSON 2**  ENGAGE activity: Observe working ROVs being used to monitor or improve aquatic ecosystem health. Refine our own ROV mission.  **Practice**: Defining problems  EXPLORE activities: Run a test mission with our own ROVs.  **Practice: Obtaining**, evaluating, and communicating information.  EXPLAIN activity:  **Practice**: Constructing explanations and designing solutions.  ELABORATE activity: Run a real mission with our own ROVs.  **Practice**: Obtaining, evaluating, and communicating information  EVALUATE activity: Analyze ROV mission data, making a claim supported by evidence with reasoning about the results.  **Practice**: Evaluating and communicating information, constructing explanations and designing solutions. | **NGSS (WSSLS) ADDRESSED LESSON 4**  Three Dimensions of NGSS  **blue=Practice orange=DCI green= Crosscutting Concept**  [5-ESS3-1](https://www.nextgenscience.org/dci-arrangement/5-ess3-earth-and-human-activity) Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.  [MS-ESS3-1](https://www.nextgenscience.org/pe/ms-ess3-3-earth-and-human-activity) Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. |

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| **TEACHER PREP LESSON 4**  In this section, students will run all fully-functional ROVs in an actual field mission. Of course, if your class is unable to visit a public dock, you may need to run your missions in a public swimming pool, or even a deep stock tank set up on your school grounds. This will certainly need to be drained while not in use for safety.   * Finalize all field trip plans, confirm lunches, meds, and chaperones, send home letters, and gather permission forms. * Arrange to meet community partner (if applicable) at the mission site. * Set up test tank/s one last time for practicing the ROV mission. * Have students pack ROVs and all materials they will need to bring to the mission site, including tool kits, spare parts, power sources (marine battery), speakers (if using hydrophones), and your chosen device with a screen, if using cameras. * Pack an appropriately-fitting life jacket for as many students who will be on a dock or boat at one time. * If the mission is a research mission, review the Process of Science and the online training, [“Guiding the Process of Science” module.](https://vimeo.com/492271775/3bd93ef750?su_via=got&login=true#_=_) |

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| **MATERIALS LESSON 4**    **Research Question formation and variable ID**   * Large, colored construction paper, cut into strips * 3 colors of 3x3 sticky notes, 1 set for each Explore Team * Box of colored markers, 1 box for each Explore Team   **Research Voyage**   * All required outdoor field trip supplies, permissions, meds, meals, and more * ROVs and sensors (camera, hydrophone, etc) * Cell phone, tablet, or other screen and cords/jacks required to display camera, hydrophone, or other sensor input * ROV tool kits * ROV spare parts * Marine deep cycle battery * Measuring tape, other research materials * Student journals for data tables * Ziploc bags for journals in case it is raining   **Graphing data**   * Graph Choice Chart, 1 per pair of students * Prepared paper graphs or a spreadsheet graphing platform, such as Excel or Google Sheets, set up for your research questions ahead of time and able to be displayed for the whole class. | **WEBLINKS LESSON 4**    Underwater robot cleans ocean trash  <https://www.youtube.com/watch?v=gWFM96CdvTg>  How Science Works Web Interactive by HHMI  <https://media.hhmi.org/biointeractive/click/understanding-science/#/intro/1>  Graph Choice Chart – U of Maine  <https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/EfBXLbU3oTxFiOag-xOm-fwBWGnN1EyCcO_3sNlVCshicQ?e=Y12E3w>  Get CERIAs form and forum instructions  <https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/ES07AeIWQklAhvBL-lTf6sUBnwm3LZVUW_2lZJvThWhFmQ?e=bKIdSt>  Oceanographer careers website [https://oceanservice.noaa.gov/facts/oceanog- rapher.html](https://oceanservice.noaa.gov/facts/oceanog-%20rapher.html)  Oceanographer careers website  Unit 5 Ocean Tech Post Assessment <https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EUDyn0DxYehMkivsB5P7ULQB_Y1DsD4hNbzPVKzhFidd0w?e=Uz61O8> |

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| TIME | **TEACHER GUIDE LESSON 4:** How can we use our remotely operated vehicle to gather evidence or mitigate impacts of humans on Earth systems near a dock? |
| Session 1  5 MIN  10 MIN  30 MIN  5 MIN | **ENGAGE**   1. Show the [CBS video clip,](https://www.youtube.com/watch?v=gWFM96CdvTg) Underwater robot cleans ocean trash. Ask what sensors or instruments that ROV used to accomplish that mission. Ask Explore Teams if their ROVs have the right instruments on board for their mission. 2. Invite students to return to **journal p25** and add the instrument that will help the ROV complete the mission if they have not already. Instruments may include a scoop, a camera, a hydrophone, or a temperature sensor.   **EXPLORE**   1. Allow time for students to add or refine instruments to their ROVs and test them out in the test tanks. 2. Have Lab Techs direct clean up. |
| Session 2  10 MIN  10 MIN  10 MIN  10 MIN  10 MIN | **EXPLAIN**   1. Allow time for teams to discuss the fitness of their ROV for their mission and revise their scale ROV drawings on journal p25. Invite their Chief Communications Officer to report to the class on their ROV’s readiness and fitness for the mission. Thank them for the reports and***, if the mission includes conducting scientific research, go on to steps 6-9.*** If you are not conducting research with the ROVs, skip these steps and journal **pp30-33** and **35**.   **ELABORATE**   1. Show **slide 50** and direct students to the HHMI How Science Works interactive Flowchart in their **journals, p30,** [or online](https://media.hhmi.org/biointeractive/click/understanding-science/#/intro/1). Ask them to consider their ROV mission and ask where in the process of science they are now. Give them a moment to consider with their Explore Teams, then circle each step they have done and draw arrows between them to indicate the order in which they were taken. If they are using the interactive flowchart online, they will simply click each step and they will see it pop up as a box in order on the left. (These boxes can be exported to PowerPoint to create presentations). 2. Show students their Research Rubric on **journal p35**. They can refer to this as a checklist as they work through their own process of science. No matter where students start in the flow chart, they will need a well-written question to guide their research. Hand out a large, colored strip of construction paper and colored markers to each Explore Team. Let them know this is for sharing the ROV research question. If they choose a comparison investigation, such as trash near a dock vs. away from a dock, starting their questions with Is, Are, Do, Does, or Will each result in a yes-no answer can help to quickly define their research results. Use **slide 52** to guide question formation. Have Explore Teams write their questions on a large, colored strip of construction paper, **slide 53**. 3. When Explore Teams have written their research questions, introduce variables, or the factors in the investigation being compared, measured, or kept the same, **slides 53-55**. Hand out 3 labeled, differently colored sticky notes to each team. One color should say Compared or ***Changed Variable*** (the factor being compared, i.e., distance from dock, water depth, etc., and one color sticky note should say ***Measured Variable*** (the factor being measured, i.e. plastic garbage count, number of species, habitat type, etc. A third color of sticky note should say ***Controlled Variables***. Have Explore Teams identify each type of variable within their question and place the appropriate sticky note just under or on the word indicating that variable in their research question, as in **slide 53**, **photo 2.** Finally, have Explore Teams list at least 3 controlled variables, which are all the factors that should be held constant, i.e., time of year, time of day, distance ROV travels along a line, etc., on the third sticky note and place it to the side of the question. A demonstration of teaching this process is shown in the “Process of Science” online training module. 4. Invite the Science Communicators to post their team’s questions where all can read them. Hold a vote to select one of these questions for the class to investigate together. Guide question and variable revisions as necessary. With one research question in hand, the class may decide on a suitable research title. The title should describe the mission. |
| Session 3  15 MIN  15 MIN  15 MIN  5 MIN | 1. Ask what they think the answer to their research question will be and have them write their hypotheses (everyone’s may be different) with reasoning on **journal p31**. Show slide 55 and remind students that they have explored many types of background information to inform their hypotheses. This is important because they must show reasoning in their hypothesis. 2. Ask how the students will complete their mission and gather the data they need to answer their research question. Invite them to first draw a picture of the ROV in action on **journal p32.** Next have students write the steps they will take to complete the mission and gather their data also on **journal p32**.Ensure they include a step that says to repeat preceding steps to get replicate samples for a representative picture of the habitat. For example, if they are counting trash or wildlife 1 meter from the dock vs. 5 meters from the dock, each team could run their ROV along a “transect” line parallel to the dock at these distances from the dock. Then there would be 5 or 6 (your number of teams) replicate samples. 3. Have students prepare their data table on **journal p33**, so it is ready for the Research Associate to record during the ROV mission. 4. Direct Chief Scientists to ensure their Explore Teams have ROVs, spare parts, and tool kits prepared for transport to the mission site. Give reminders of field trip details. |
| Session 4  time will vary | 1. Field trip. Conduct your ROV mission according to the students’ plan. Enjoy the adventure!   \*\*Sustainability Stars: Bring a net to fish any lost parts out of the water. We want to decrease marine debris, not add to it! |
| Session 5  10 MIN  15 MIN  20 MIN | **EVALUATE**   1. Congratulate your marine engineers on a mission accomplished! Have your engineers-scientists-ROV pilots complete their final ROV Dive Log 4,  **journal p27.** 2. Ask who wants to see what their data revealed about their research question. Share that a graph is a way of turning evidence into a picture that everyone can understand. And that having the right picture to reveal the mystery is key! Distribute the [Graph Choice Chart](https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/EfBXLbU3oTxFiOag-xOm-fwBWGnN1EyCcO_3sNlVCshicQ?e=GyLwQo) and challenge teams to choose the best graph for the job. 3. Have students plot their data on a class graph in a graphing program, such as Excel, Google Sheets, another of your choice, or by hand on a poster paper that can be displayed for the whole class. Each Explore Team will add their own data to the graph as a replicate sample. Optional: Once it is plotted, have them sketch the graph into their own **journals, p 33**. |
| 20 MIN  20 MIN  10 MIN | 1. Show **slide 59,** and follow the [Get CERIAs instructions](https://pacificeductioninstitute.sharepoint.com/:b:/s/Program/ES07AeIWQklAhvBL-lTf6sUBnwm3LZVUW_2lZJvThWhFmQ?e=JKYQd1) to guide students through the Get CERIAs **journal p34** form and dig consider the meaning of their mission results.      1. Hold your Get CERIAs forum, according to the instructions and be amazed at the ability of your students to analyze their results, argue over their meaning (politely), and consider the implications and applications of their new knowledge. 2. Afterward, have students evaluate themselves using the ROV Rubrics (journal p28 or 29) and, if applicable, the ROV Research Rubric, **journal p35**. Stamp student journals to celebrate, **journal p36**! Show students a video by Ocean Networks Canada about possible careers in Ocean Tech, **slide 58.** 3. Gather journals and record students’ self-assessments. Save journals for Unit 8 when students will review their Get CERIAs applications recommendations to select a Salish Sea Heroes project. |

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| 20 MIN | 1. A picture containing text, sign     Description automatically generatedAdminister the Ocean Tech [Post-Assessment](https://pacificeductioninstitute.sharepoint.com/:w:/s/Program/EUDyn0DxYehMkivsB5P7ULQB_Y1DsD4hNbzPVKzhFidd0w?e=Fg3GdK) and compare results to students’ pre-assessment to measure student growth in unit 5, **slide 59**.   Remaining slides are for those opting to add a lesson on sound to support the addition of a hydrophone (underwater microphone) to students’ ROVs. |

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| MATERIALS:  **Research Question formation and variable ID**   * Large, colored construction paper, cut into strips * 3 colors of 3x3 sticky notes, 1 set for each Explore Team * Box of colored markers, 1 box for each Explore Team   **Research Voyage**   * All required outdoor field trip supplies, permissions, meds, meals, and more * ROVs and sensors (camera, hydrophone, etc) * Cell phone, tablet, or other screen and cords/jacks required to display camera, hydrophone, or other sensor input * ROV tool kits * ROV spare parts * Marine deep cycle battery * Measuring tape, other research materials * Student journals for data tables * Ziploc bags for journals in case it is raining   **Graphing data**   * Prepared paper graphs or a spreadsheet graphing platform, such as Excel or Google Sheets, set up for your research questions ahead of time and able to be displayed for the whole class.   RISK MANAGEMENT:  Review your school’s safety guidelines for field trips near or on the water.  Always have students wear life vests when working with ROVs from a dock or boat. | ONLINE RESOURCES  [Understanding Science website for teachers](https://undsci.berkeley.edu/understanding-science-101/how-science-works/the-real-process-of-science/)  [How Science Works Web Interactive by HHMI](https://undsci.berkeley.edu/lessons/pdfs/flowchart_35.pdf)  Grades 3-5 [How Science Works Flowchart](https://undsci.berkeley.edu/lessons/pdfs/flowchart_35.pdf)    **\*Note on lessons and time:**  Use the lessons and activities herein as you see fit and feel free to modify documents and slideshow to fit your teaching needs. For this reason we have left them as Word or PowerPoint files. Just be sure that there is still a logical developmental progression, as described in the NGSS Ap-  pendix E-Progressions Within the Next Generation Science Standards: https://[www.nextgenscience.org/sites/default/files/re-](http://www.nextgenscience.org/sites/default/files/re-) source/files/AppendixE-ProgressionswithinNGSS-061617. pdf |